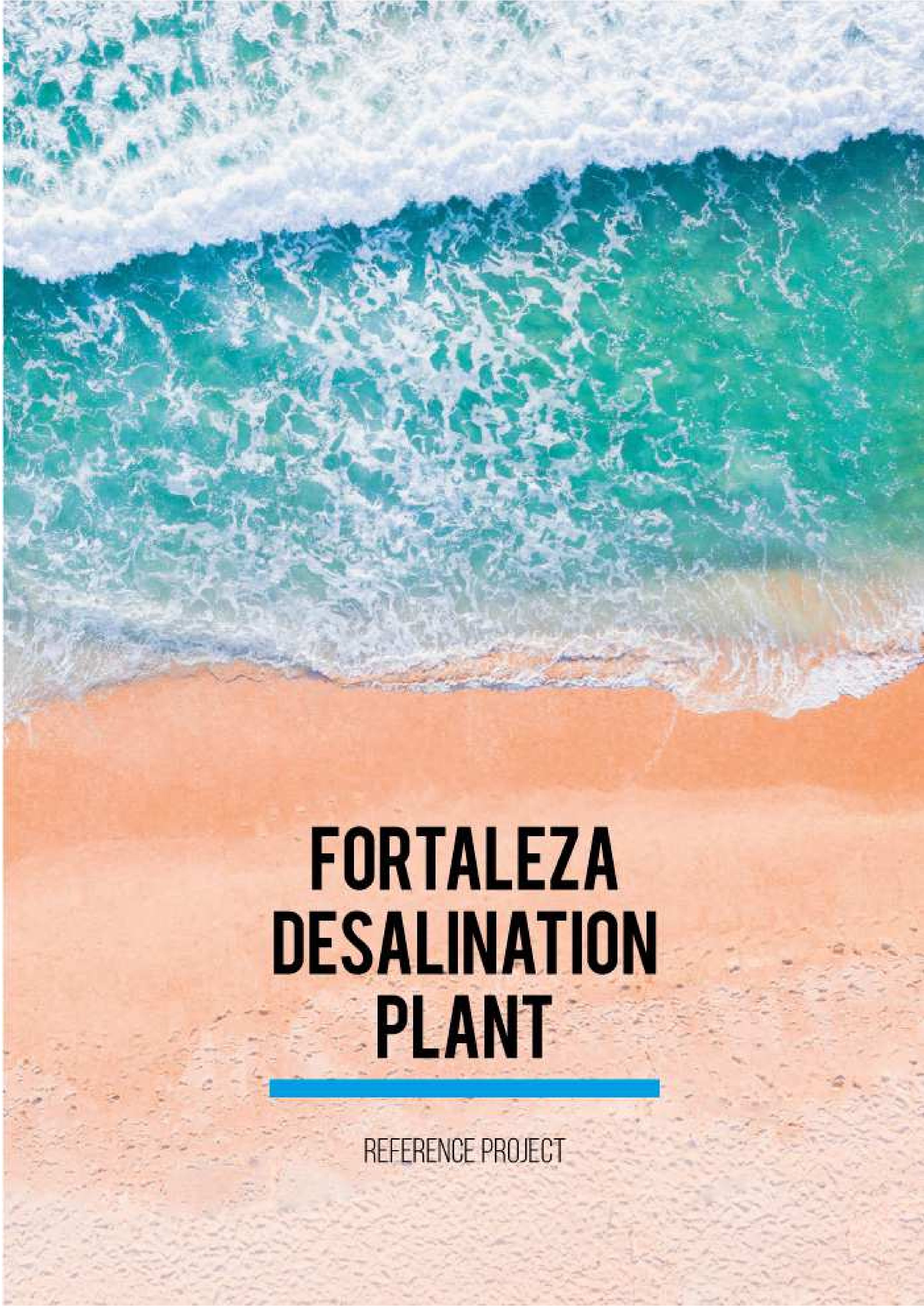

# FORTALEZA DESALINATION PLANT

REFERENCE PROJECT

# GENERAL SUMMARY





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# Presentation

This material corresponds to the review of Study 4 – Engineering Preliminary Project, originally delivered by GS Inima Ltd., the leading company authorized to develop this and the other 14 (fourteen) studies elaborated in the scope of the Public Notice for the Expression of Interest Procedure – PMI 01/2017/CAGECE, whose objective was the Elaboration of Studies for a Sea Water Desalination Plant for the Fortaleza Metropolitan Region, with capacity for 1 $m^3/s$.

The objective of this report is to present a Reference Project that shall serve as basis for the elaboration of the executive project of implementation of the Fortaleza Desalination Plant, describing the alternatives studied, technical concepts, data acquired and constructive solutions for the various units that may be part of the system.

This report is divided in fifteen chapters: Chapter 01 – Introduction, presents the current water supply situation of the State of Ceará and incorporates the desalination proposal within this context. Chapter 02 presents the location alternatives for the implementation of the desalination plant, as well as the alternative chosen and the main considerations concerning the same. Chapter 03 presents a general review of reverse osmosis technology. Chapter 04 details each process and methodology used in a desalination plant that utilizes the processes and system of a reverse osmosis plant. Chapter 05, describes the configuration of the desalination plant proposed for Fortaleza. Chapter 06 discusses all the construction works that will be necessary for the plant's implementation. Chapter 07 presents the general characteristics of the electrical installations related to the plant. Chapter 08 discusses the architectural solutions proposed for the implementation of the desalination plant. Chapter 9 discusses the field devices that shall be installed in the plant, as well as the control system to be adopted. Chapter 10 discusses the interconnection of the plant with the current CAGECE system and its peculiarities. Chapter 11 presents the chronogram and the summarized budget for the necessary construction works. Chapter 12 displays the presentation of the pilot plant and all consideration necessary in its analysis. Chapter 13 presents the relationship between all the drafts composing the present volume. Chapter 14 presents the Attachments that complement this Reference Project and, at last, Chapter 15 presents the teams responsible for reviewing, complementing and preparing this Reference Project.


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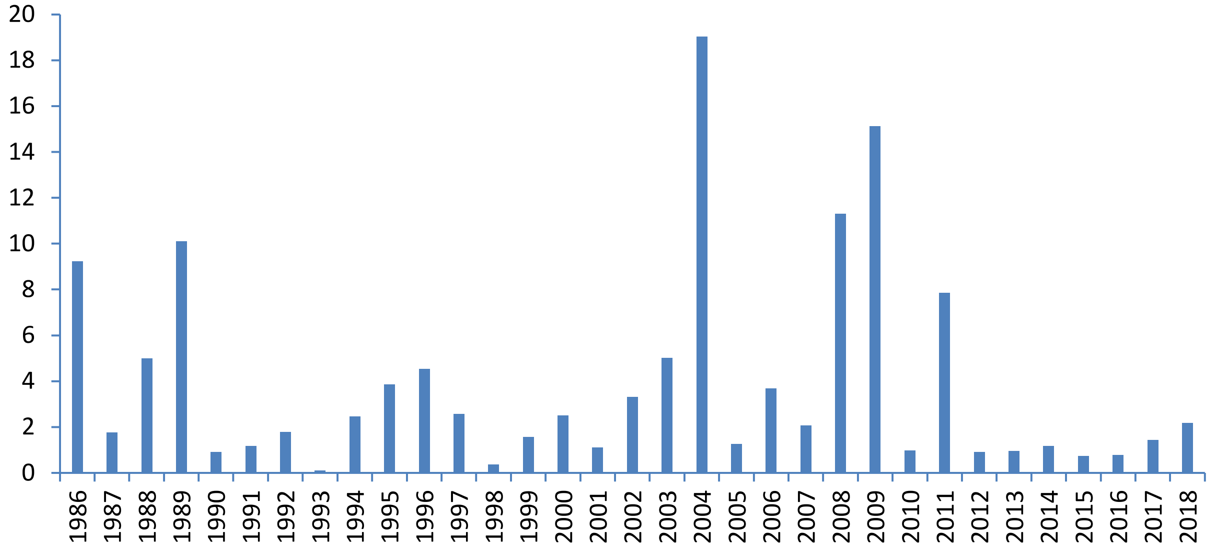
# 1. Introduction

The state of Ceará is characterized by long cyclical periods of rainfall scarcity, currently facing its seventh consecutive year of rainfall below historical average, as illustrated in the figures below. This peculiarity has been the object of numerous studies that seek a greater understanding of its variability and associated natural mechanisms, but its behavior is not yet fully understood.

Figure 1.1 – Evolution of the State Springs Water Supply




The interference of today's civilization in environmental changes on a global scale, as evidenced by the consequences of $CO^2$ emissions, reinforces the concern that human activities may negatively impact the ecosystem, not only on a local sphere. The latter is represented, for example, by the impacts of human action on hydrographic basins, which contribute to increased evaporation and aggradation, while the former is represented by changing global circulation patterns that lead to changes in rainfall regimes, increasing the occurrence of severe events (droughts and floods).

As a strategy to minimize the deleterious effects of this region's characteristic condition, several small, medium and large reservoirs were built over the decades, with Castanhão, Orós and Banabuiú being the largest. Canals and transposition systems that carry water to the main supply system (Jaguaribe Metropolitano) were built as well, as illustrated in the figure below.



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Figure 1.2 - Water network that supplies the Metropolitan Region of Fortaleza, with no interconnection to the São Francisco River integration.


In the current scenario, where new challenges are posed, actions different from those traditionally adopted may complement previous solutions, adding security to the system that did not previously address the present uncertainties. In this perspective, Cagece has been required to provide supply alternatives to strengthen the state's water matrix, especially that of the Metropolitan Region of Fortaleza; it is responsible for the highest demand of water for human consumption and is heavily dependent on water imports from foreign basins.

Among the available alternatives, seawater desalination has long been discussed as a possible source to diversify the state's water matrix – so much so that, in the Ceará State Water Resources Strategic Plan, prepared in 2009, seawater desalination was embedded at various points in the text, as can be seen below:

> When the large and medium-sized buses and the support capacity of the San Francisco interconnection planned for 2020 are exhausted, it is worth asking: what other alternative sources will guarantee water for future generations? Will it be possible to count on the Tocantins Basin interconnection? Or is it necessary to immediately start studies on the future alternative use of seawater desalination to supply the inexorable population and industry growth of the Metropolitan Region of Fortaleza and Pecém Port?[1]

In agreement with the aforementioned document, more recently, the Fortaleza 2040 Plan, which establishes strategies to be implemented in the short, medium and long term in urban areas, for mobility, economic and social development of the municipality, to be commenced on 2040, explicitly considers the city's need to rely on this new source to complement its supply.

1 Available at: https://www.srh.ce.gov.br/wp-content/uploads/sites/90/2018/07/PLANO-DE-ACOES-ESTRATEGICAS-DE-RECURSOS-HIDRICOS-CE_2018.pdf



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Table 1.1 - Plan of Action for Alternative Water Sources Projected in the Fortaleza 2040 Plan.

**Quadro 21 – Linha de ação 4 – Mananciais alternativos**

| Nº | AÇÃO | META | INDICADORES | PRAZO | LOCAL | EXECUTOR |
|---|---|---|---|---|---|---|
| SH.4.8 | Concepção de estudo de análise de viabilidade técnica, econômica e ambiental da dessalinização da água do mar | 01 estudo | Estudo realizado | 2017 | Toda a cidade | SRH/ Cogerh |
| SH.4.9 | Construção e operação de planta de dessalinização | 01 planta dessalinizadora | Planta operando | 2022 | Toda a cidade | Concessionária dos serviços |

Source: Fortaleza 2040 Plan: Environmental and Natural Resources Quality / Fortaleza City Hall. – Fortaleza: Iplanfor, 2016

The reasons for this particular interest in the population of Fortaleza and integrated municipalities' water supply are summarized below:

- Desalination produces higher quality water than the potability standard processes, and with high stability;
- It is a worldwide accepted practice for human supply purposes, being easily acceptable;
- It uses an unlimited source, the sea, to produce drinking water, with no interference from climate change;
- Enables a reduction in the use of conventional water resources;
- The proximity of the population served to this new source



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# 2. Selection of Alternative Locations

A total of eleven areas were studied for the possibility of desalination plant installation, distributed among the municipalities of Fortaleza and Caucaia as follows:

- Area 01 (Sabiaguaba), located in the Sabiaguaba Beach region, east of the Cocó River;
- Area 02 (Serviluz), which is located in the Praia do Futuro region, more specifically in the Serviluz Community area;
- Area 03 (Mucuripe), located at *Ponta do Mucuripe*, at Mansa Beach;
- Area 04 (IPLANFOR I), located in the Praia do Futuro region, on Hermínio Bonavides street;
- Area 04-A, called Praia do Futuro I-A, located four blocks southeast of the originally proposed land area called IPLANFOR I;
- Area 04-B, called IPLANFOR I-B, which is located one block north of the originally proposed area known as IPLANFOR I;
- Area 05 (IPLANFOR II), located in the Praia do Futuro region, on Dr. Aldy Mentor Avenue.
- Area 01 (Cumbuco I), located in the Praia do Cumbuco (Caucaia) area, next to *Vila do Cumbuco*;
- Area 02 (Cumbuco II), located in the Praia do Cumbuco (Caucaia) area, near Vila Galé hotel;
- Area 01-A (*EPC*), located near the start of the marine outfall of Fortaleza's Sewage Pretreatment Plant (*EPC*);
- Area 02-A (Iparana), located near Iparana Beach (Caucaia).

The alternative that presented a better set of favorable attributes to desalination plant installation was the area called Praia do Futuro I-A, which is presented below. Details on the other areas and the selection process can be found in the "Location Alternatives Studies R03".

## 2.1. Selected Area

The selected area corresponds to a regular land area formed by two partially unoccupied blocks separated by an unconsolidated street, as shown in Figure 2.1. The total area corresponds to 2.3 ha, with 2 hectares corresponding to the two blocks. The main access to the desalination plant area shall be through Francesco F. Dângelo Street and Dioguinho Ave., which has its south access mainly by Santos Dumont Ave., and to the north by José Sabóia Ave. The nautical charts indicate a depth of 12.0 m at a distance of 1.1 km from the coast.



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Figure 2.1 - Area 04-A Site (Praia do Futuro I-A).

The interconnection with Cagece's water supply system shall take place at two different sites: the Mucuripe Reservoir, located at Morro Santa Teresinha, the same delivery point originally proposed by the Authorized Company, and the Aldeota Reservoir, located at Chanceler Edson Queiroz Imprensa Square, as shown in Figure 2.2. For the alternative in question, a DN1000mm HDPE pipe is proposed, which shall start from Francesco de F. Dângelo Street to Dolor Barreira Ave., in a northbound direction, with an approximate length of 1.343 km. Starting from José Aurélio Câmara Street, the pipe will be divided into two sections. The first will extend through Dolor Barreira Avenue in a HDPE DN710mm pipe until the Mucuripe Reservoir, for about 1,196km. The second, approximately 5,277 km long, will extend until the Aldeota reservoir in a DN800mm HDPE pipe, running through Fausto Cabral, Prisco Bezerra, Amelia Benebien, Julio Azevedo, Vilebaldo Aguiar, Av. Engenheiro Santana Júnior, Av. Santos Dumont, Rondon, Eduardo Garcia, Vicente Leite, General Tertuliano Potiguara and Visconde de Mauá streets.

Figure 2.2 - Plant Interconnections Located at the Praia do Futuro I-A Area – Floor Plan




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## 2.2. Interconnection with the Cagece System

The interconnection of the Desalination Plant to the Cagece System shall be made by HDPE pipes, with diameters of 710mm, 800mm and 1000mm, as previously presented.

Pipeline installations shall take place, for the most part, through the conventional method of open cut trenching (destructive method), with a milling service of 3.00 meters in width to be provided for the entire pipe layout.

The Mucuripe Reservoir feeds the distribution network through three separate lines, two working by gravity and one by a pumping system, to satisfy locations with the highest demand. There are two gravity lines: one with a diameter of 550 mm, feeding the Papicu, Varjota and Cidade 2000 districts; and another with a 600 mm diameter, serving the Praia do Futuro, Caça e Pesca, Cais do Porto (Serviluz) and Vicente Pinzon areas. The pumping station deployed adjacent to the supported reservoir serves the highest part of the Dunas District.

In the Mucuripe Reservoir, system interconnection will happen at two points. The first will be directly on the pipeline that serves the most elevated area, therefore nullifying the existing pumping station. The second point shall be placed directly in the reservoir, from where it can supply all other areas.

The Aldeota Reservoir feeds the distribution network of the Aldeota District and surrounding areas through two 700 mm pipes. Its interconnection with the main line from the desalination plant will be directly on the distribution outlet, where measuring equipment will be installed to monitor flow rates.



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Figure 2.3 - Mucuripe Reservoir Location (Morro de Santa Teresinha).


Figure 2.4 – Aldeota Reservoir Location (Imprensa Square)




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## 2.3. Possible Interferences

Figure 2.5 – Water Main Interconnection with the Existing System




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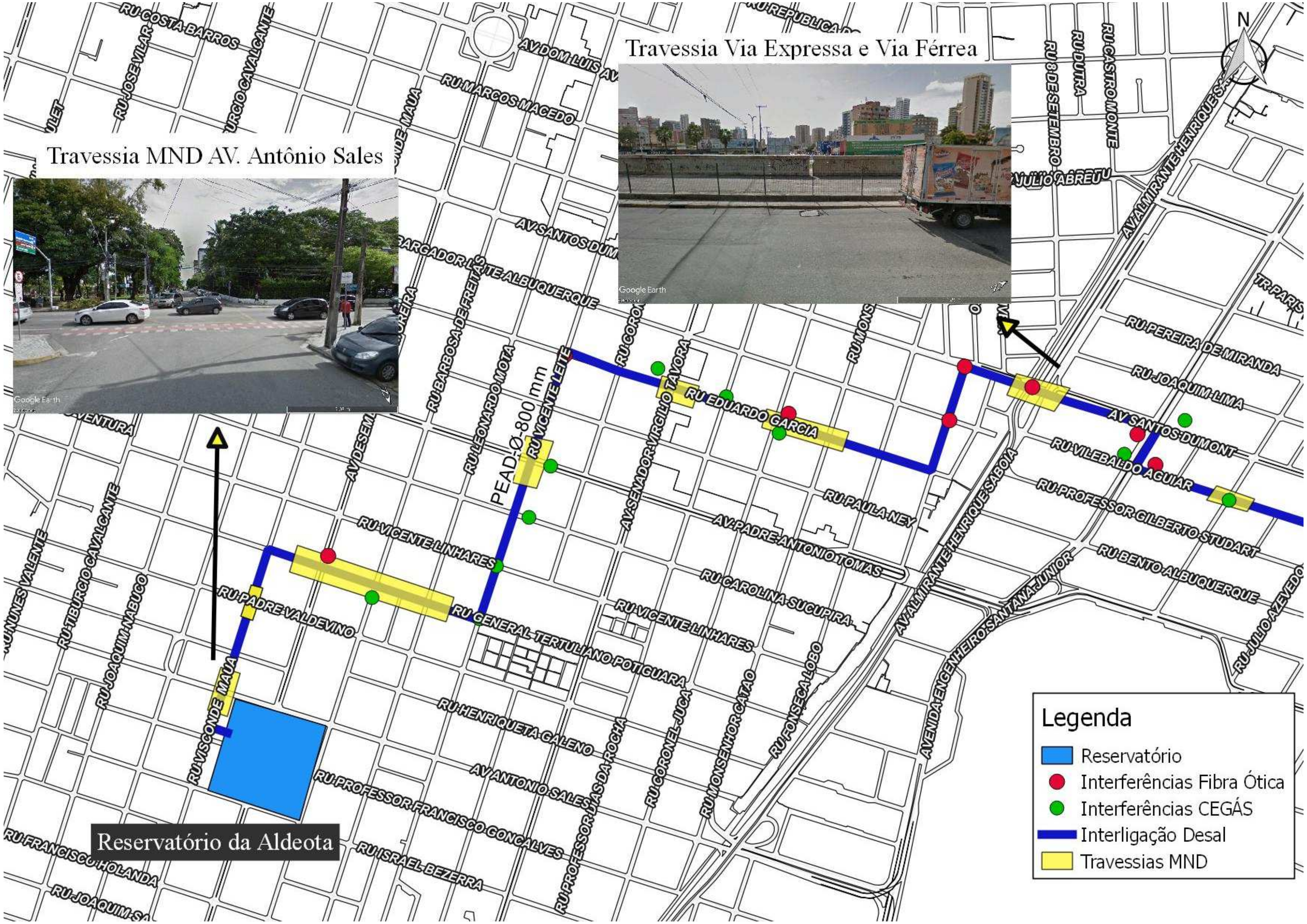
Figure 2.6 – Interferences of the Interconnection Water Main with the Existing System



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Since it is an extremely dense urban area and of industrial use, it is inevitable to observe interferences with several existing networks already existent in its path (water, sewage, gas, fiber optic cabling, drainage and railways).

Figures 2.5 and 2.6 show the possible interferences found along the desalination plant interconnecting water main with the existing Cagece system. Interference with gas pipelines, fiber optic cabling, high traffic routes, railways, drainage galleries, as well as water distribution and sewage collection networks are observed.

From the plant’s output until the fork of the line, between Av. Dolor Barreira and Rua José Aurélio Câmara, it is possible to observe interference with fiber optic cables, as well as the water distribution networks.

In the section that extends from the bifurcation to the Mucuripe Reservoir, interferences with fiber optic cabling and gas and water distribution pipes are observed.

The most critical stretch is bifurcation that extends to the Aldeota Reservoir. In its path there are several interferences (water distribution and sewage collection networks, gas piping, fiber optic cabling, high traffic streets and railways). Non-destructive road crossings will be required mainly on high traffic avenues (Av. Santos Dummont, Av. Almirante Henrique Sabóia, Av. Senador Vigílio Távora, Av. Padre Antônio Tomás, Av. Desembargador Moreira, Av. Antônio Sales and Desembargador Lauro Nogueira, Desembargador Valdetário Mota, Monsenhor Catão, Coronel Jucá, Leonardo Mota, Barbosa de Freitas and Padre Valdevino Streets), as well as in the railways parallel to Av. Almirante Henrique Saboia.

The main interferences with drainage galleries were found in Francesco de F. Dangelo, Prisco Bezerra, Amelia Benebien, Almeida Prado, Júlio Azevedo and Tomás Rodrigues streets and the intersection between Vilebaldo Aguiar and Valdetário Mota streets.

Possible interferences with the water distribution network are found at the following streets: Dolor Barreira, with pipes at DN400 and DN250; Fausto Cabral, with pipes at DN200; the intersection of Amélia Benebien and Solon Onofre streets, with pipes at DN250, DN300 and DN500; Vilebaldo Aguiar, with pipes at DN250; Engenheiro Santana Júnior Ave., with pipes at DN550; Santos Dumont Ave., with pipes at DN250; at the intersection of Vicente Leite Street with Padre Antônio Tomás Ave., with pipes at DN550, DN250 and DN300; at the intersection of General Tertuliano Potiguara and Barbosa de Freitas streets, with pipes at DN550 and DN250; at the intersection of General Tertuliano Potiguara Street with Desembargador Moreira Ave., with pipes at DN500 and DN250 and at the intersection of Visconde de Mauá Street with Antonio Sales Ave., with pipes at DN1000 and DN 300.

The main interferences with the sewage system were observed at streets Júlio Azevedo Street, with a reinforced concrete pipe at DN1000; at the intersection of streets Desembargador Lauro Nogueira and Júlio Azevedo, with a reinforced concrete pipe at DN1000; at the intersection of Santos Dumont Ave and Marechal Rondon Street, with a pipe in DN300; at the intersection of Eduardo Garcia and Coronel Jucá streets, with a pipe at DN200 and at the intersection of Vicente Leite and Vicente Linhares streets, with a pipe at DN250.

The water mains that interconnect with the macrosystem shall be implemented in high traffic roads and, even with use of the non-destructive method (NDM) on the main roads, traffic deviations will be necessary. Thus, the Municipal Traffic and Citizenship Authority (AMC) of Fortaleza must be


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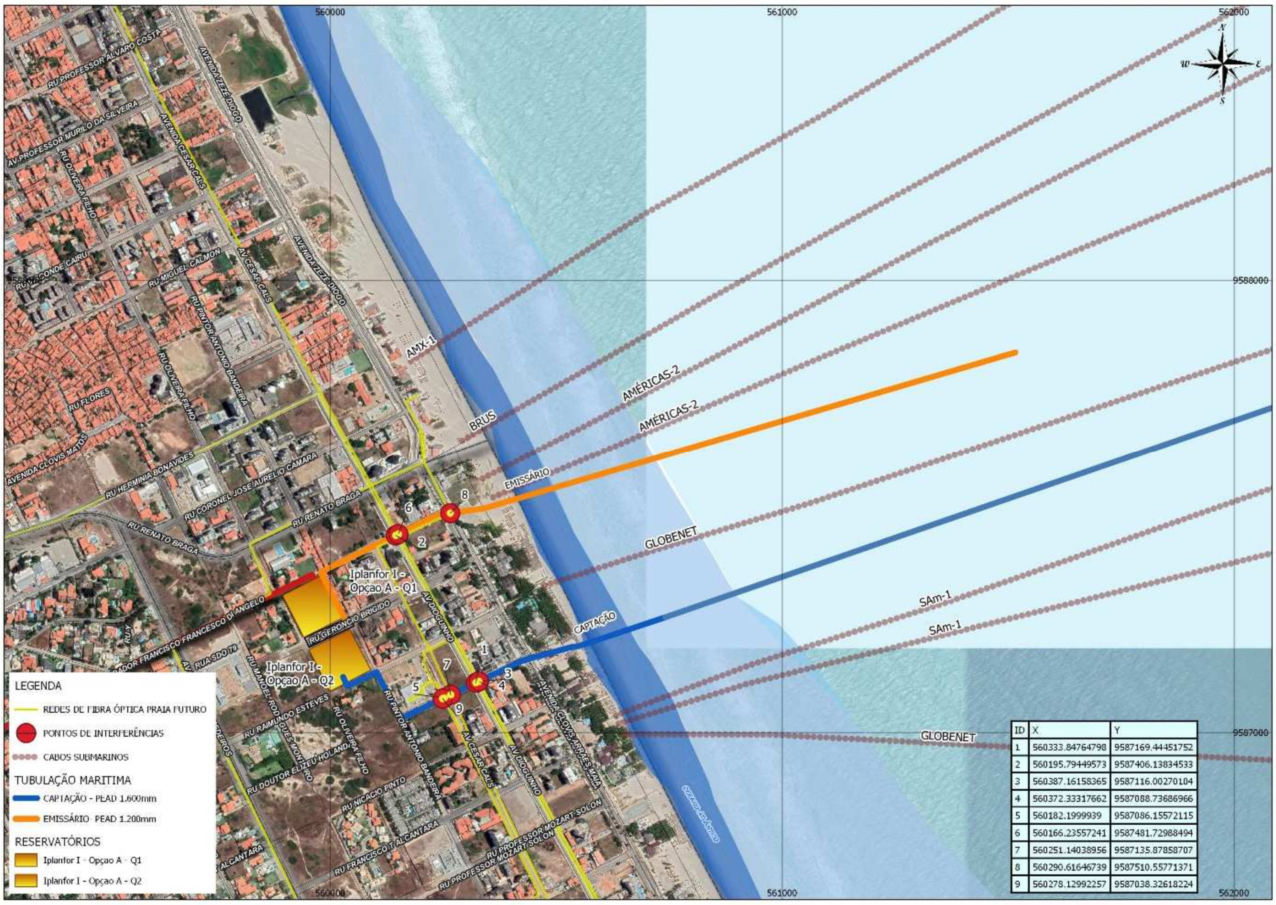
notified in advance in order to carry out traffic deviation studies that will mitigate the inconvenience caused by the work.

Marine interferences shall be considered in addition to the terrestrial, since the region is an important submarine cable hub, as shown in Figure 2.7. However, it is not limited to the aforementioned interferences. To reduce interference with submarine cables and guarantee the structural integrity of the intake and outfall systems, a current topobathymetric mapping of the coastal zone shall be necessary, for the surface and submerged areas. In addition, cable operating companies in the region must be consulted.

Figure 2.7 – Marine interferences




## 2.4. Considerations on the Alternative Chosen

The alternative chosen shall allow the Mucuripe Reservoir region to save energy. It is currently supplied by a booster called São Pedro, which shall be directly supplied by the flow from the desalination plant pipeline, thus enabling the booster's deactivation.

In addition, the plant will serve the two supply areas (Mucuripe and Aldeota) through only one pumping station, which will be located in the desalination plant itself.

The flow from the water mains at the two chosen points shall allow for the entire flow produced in the desalination plant to be met, however, the system has been designed so that, in special occasions, when the Mucuripe Reservoir is full, all the water produced by the plant can be sent to the Aldeota branch.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# 3. Sea Water Desalination

The earliest historical references to the separation of water and salt in seawater date back to Ancient Greece, where Aristotle, Thales of Miletus, Democritus or Pliny began to work on the idea of seawater evaporation and subsequent condensation, to separate it from its salts. The first sand filtration experiments to purify water also date back to this time. From a practical standpoint, there are fourth-century ecclesiastical writings that clearly describe the procedure used by sailors to distill seawater. It consisted in filling cauldrons with salt water, that then were placed on a powerful fire. Above the cauldron were sponges that absorbed the steam that had been released as the seawater boiled. Later, the sailors squeezed the sponges to get fresh water to drink.

From that time on, stills were developed to distill water by steam condensation and posteriorly, during the Middle Ages, many Arab and Persian alchemists also practiced sea water desalination using heat sources.

Later on, during the Renaissance, some Arab alchemists began to use solar energy for seawater desalination. They used glass vases in which they put seawater, then heated it with mirrors that reflected solar radiation to the vases, thus yielding the heat. required for water evaporation.

After the discovery of America, the start of long sea voyages helped to slightly improve the seawater distilling process, since it was more profitable to transport a distiller than large quantities of drinking water.

In 1675, the first patent on desalination was registered, but it was not until 1872 that the Swedish engineer Carlos Wilson built the first industrial-sized desalination plant in Chile. It was a Solar facility of 4,757 $m^2$, with a production capacity of 22.5 $m^3$ / day.

In the early 20th century, some portable desalination units were built, especially designed for use in war to guarantee a water supply to the soldiers.

The first of the modern large-scale desalination processes developed was the multistage flash desalination (MSF), in the mid-twentieth century in the USA. (1955). Although multiple-effect distillation (MED) was well known and was potentially more efficient than MSF, making the MED process large-scale efficient took even longer, and it was not until 1959 that the first MED facility was built in Aruba.

In the following year, at the University of California, the first synthetic and functional reverse osmosis (RO) membrane made of cellulose acetate was produced. This membrane was able to reject salts and allow water to pass through it with reasonable flow and high pressures. At RO, pressure is the driving force of the separation process. For this the hydraulic pressure must exceed the osmotic pressure of the water to be desalinated.

After this invention, the desalination journey began with adoption of membrane technologies. In 1965, the first commercial reverse osmosis desalination plant in California was inaugurated at the Coalinga brackish water desalination plant. However, it was not until nine years later, in 1974, that the first seawater RO desalination plant in Bermuda came into operation.

From these first steps on, thermal and membrane desalination have jointly evolved towards greater energy efficiency and lower cost through technological advances, the use of economies of scale and the optimization of different desalination processes.

## 3.1. Desalination Technologies and Processes



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There are currently several water desalination processes, all based on the observation of natural phenomena of water and salt separation. Thus, evaporation-based processes are the attempt to mimic nature when, through the sun, it evaporates seawater and forms clouds, that eventually come down as rain or snow, allowing us to have fresh water in rivers, lakes, wells, etc. The desalination process based on freezing seawater is also a consequence of the observation of nature. At the poles, when water freezes, it contains no salts, leaving it in the surrounding seawater. Observing how plants absorb water from the soil or how our body cells absorb water and flush out toxins has resulted in the emergence of water desalination processes using semipermeable membranes. Thus, all water desalination processes are based on some of these elementary principles taken from nature. The difference of the commercial processes is in trying to be as efficient and economical as possible when separating water and salts in a facility. Without trying to be exhaustive, the most important evaporation processes that have existed and exist today are: Multistage Flash Evaporation, Multi-effect Evaporation, Mechanical Vapor Compression, Thermal Vapor Compression and Solar Distillation.

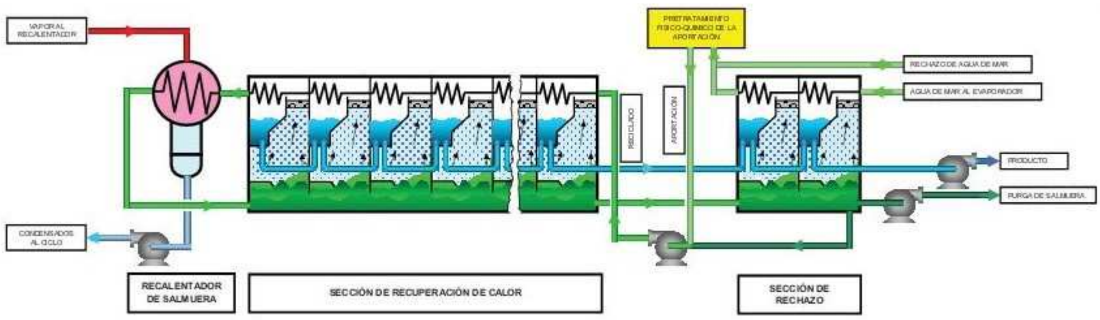
The main membrane desalination processes include Reverse Osmosis, Reversible Electrodialysis and Nanofiltration.

### 3.1.1. Multistage Flash Evaporation (MSF)

The *Evaporação Instantânea Multietapa* process is also known by its English acronym, M.S.F., which corresponds to Multistage Flash Evaporation.

The idea of this process is to distill the seawater and condense the steam obtained, recovering the latent heat to heat up more seawater, that will later evaporate. If the heat transmission had an infinite area and infinite number of stages, with no losses once the process started, there would be no more heat and the process would continue, but since this is thermodynamically impossible, it is necessary to have an external source of energy to provide the necessary temperature increase to start the cycle.

Figure 3.1 - Multistage Flash Evaporation Process Diagram




Source: GS Inima

Observing the flowchart in Figure 3.1, we will describe how the process occurs. There are three distinct sections: the first is the heat rejection section; the second is the heat recovery section and, lastly, the brine reheater. To explain this process, let's start from point "A", located on the brine recycle section to the superheater outlet field. At this point, recycling is at the maximum possible cycle temperature and is introduced into the first stage of the evaporator from the bottom. Upon entering this stage, the brine recycle is found at a lower pressure than its saturation temperature, so a portion of it evaporates "instantly" to try to balance and adjust its temperature to the pressure displayed in this stage. The steam released passes through the equipment (demersters), whose purpose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is to eliminate brine droplets that may have been carried by the steam in the sudden evaporation process.

Subsequently, the steam condenses on the outer surface of the stage condenser tubes, dripping into the suitable tray under the tube bundle, where it is collected. The recycling field, that remains at the bottom of the non-evaporating stage is conducted to the next stage, again with a lower pressure than saturation with the temperature it carries, repeating the already explained evaporation and condensation cycle therein and in the following stages until the last one is reached. Water from the seawater feed circulates through the heat rejection section pipes. At the outlet of the heat rejection stages, seawater has risen in temperature; part of it is returned to the sea as reject seawater and another stream is added to the cycle after being degassed and chemically treated, to prevent corrosion and scale. This is called make-up. The make-up stream and a portion of the remaining brine from the last stage are mixed together to form a Combined Brine Recycle Stream, which is introduced through a recycle pump into the heat recovery section stage tubes, cooling the stream to condense the vapor formed in each stage.

This recycled brine's temperature will increase as it moves toward the first stage. At the pipe outlets of this first stage, it will have gained most of the temperature necessary to start the cycle because of the recovered heat. However, it will still lack some temperature, that shall be gained by the moment it reaches the maximum cycle temperature, in the brine reheater. The condensation of external steam is the heat source that shall heat the brine recycle to the aforementioned maximum temperature. The superheater condensate is then returned to the thermal cycle from which steam comes.

The water product obtained in each stage is passed on to the next through a hydraulic closing system. This water should also balance out the prevailing pressure from each stage, partially evaporating and returning to the condensed stage on the surface of the stage tubes. Upon reaching the last stage of the evaporator, the product reaches its minimum temperature and yields all of its sensitive heat. From the product tray of this last stage, the product is removed by a product pump and sent to the storage tank.

To maintain the balance of salt concentration in the evaporator, as it is continuously introducing a quantity of salt water through the contribution of seawater, it is necessary to extract the same amount of salts to prevent its accumulation in the interior, where flow is concentrated. For this, a brine purge will be performed at the point of maximum salt concentration, with the brine from the last step.

Due to the air and gas content of seawater, as these are not completely eliminated in the pretreatment to which it is subjected and, in addition, since many stages happen under vacuum conditions, there usually is air that comes in from the outside through pores, flanges, equipment, etc. It is necessary to extract the non-condensable gases to prevent them from accumulating inside the evaporator, hindering its performance. For this, a vacuum apparatus and a network of stages are installed. This equipment is usually formed by ejectors with barometric or surface condensers.

The most important characteristic parameters related to this process are as follows:

- ✓ Economy Ratio or Performance or Economy Index or ER
  It is the ratio between the amount of product obtained by each heat unit introduced into the evaporator, measured in lb-product / 1000 BTU, which roughly coincide with kg-product / kg-steam when this steam is in a saturation condition and between 95 and 120°C, which is normal.
- ✓ Concentration Factor


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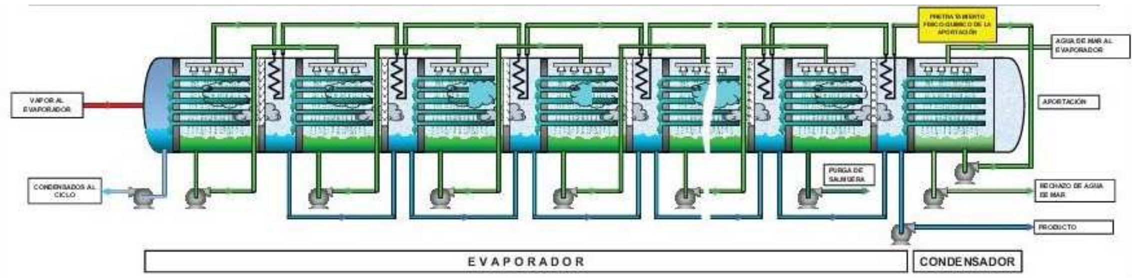
It is the quotient resulting from the division of brine Recycle concentration by seawater concentration, both expressed in mg/L or ppm.

### 3.1.2. Multi-effect Distillation

The *destilação multiefeito* process is also known by its acronym in English, MED, that corresponds to Multi-effect Distillation.

Figure 3.2 – Multi-effect Distillation Process




The idea of this process, like in all distillation processes, is to evaporate seawater, condense the steam obtained, and recover latent heat from steam condensation to heat up more seawater, that shall evaporate again. Observing Figure 3.2, we will describe how the process occurs. The evaporator is divided into two sections: the condenser, which is the coldest fragment of the evaporator, and the effects, with the first being the hot stage of the thermal cycle. To explain this process, we will start with the first effect. The steam supplied generally as a low-grade energy source is condensed inside the pipes, while, on the outside, we spray seawater that acts as a coolant, which is heated to the maximum temperature and partially evaporates. The steam produced in this first effect passes through nozzles to remove brine remains it can carry and enters the pipes of the next effect where it will be condensed, also evaporating a portion of seawater being sprayed outside the pipes. This sprayed water comes from unevaporated seawater from the first effect and is known as Feed.

It is found, in this effect, at a lower pressure than in the previous one. Consequently, it undergoes an instant evaporation process to meet the prevailing conditions in the effect and also by steam condensation within the system. The pipes, which yield condensing heat, evaporate the same amount of water. In conclusion, the steam produced in each effect comes from evaporation due to the thermal imbalance between the effects and steam condensation within the pipes. This process repeats itself, increasingly reducing the temperature at which it occurs and decreasing the corresponding pressure within each effect, until it reaches the final condenser.

In this condenser, the steam produced in the previous effect condenses; however, because the amount of seawater used to condense it is very large, no steam is produced, only the seawater’s temperature increases: it is the cold stage of the thermal cycle. At the outlet of this effect/condenser, the warm seawater stream is divided into two: one is the reject, returned to the sea, and the other is the make-up, that is pumped into the effects before the capacitor in ascending direction, from the second to last effect to the first. This make-up water is introduced into heat exchangers, which are present in each effect. They use a part of the steam produced to heat this make-up flow, until it reaches the first effect where it achieves the maximum temperature that allows it to continue the cycle. As was stated in the beginning, in this first effect hot water is sprayed on the outside of the pipes, increasing its temperature while some of it evaporates. Seawater that has not evaporated and remains in this effect is pumped for the following purposes, spraying the outside of the pipes.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The effect before the condenser is where seawater is most concentrated, since it was partially evaporated previously in the other effects. This is where brine purge will be performed to maintain salt balance in the evaporator.

The condensed steam in the first effect returns to the outer cycle from which it comes; this is the condensation of conductive steam. The condensation of the second and following effects generates the Product, which circulates from one effect to another, being inserted into a lower pressure condition every time, so part of this product water evaporates to balance out pressures and temperatures. This steam is added to the remaining steam produced in the effect, and condensed in the next one.

Thus, when the product flow reaches the final condenser, it is at the lowest possible temperature. Afterward, it is extracted by a product pump, which sends it to the plant storage tank. Since the evaporation process causes seawater to release gases that may remain and the evaporator works in a vacuum, there are always leaks and air entrances through the pores, equipment and instruments. This air accumulates inside, making it difficult to transfer heat and resulting in performance loss. Therefore, there is a set of openings in each effect, with incondensable matter extracted by vacuum equipment.

Make-up water will be chemically treated to prevent scale formation before it is introduced into the evaporator. The usual treatment is degassing and the addition of an anti-scale.

The most important characteristic parameters related to this process are as follows:

- ✓ Economy Ratio or Performance or Economy Index or ER
  It is the ratio between the amount of product obtained by each heat unit introduced into the evaporator, measured in lb-product / 1000 BTU, which roughly coincide with kg-product / kg-steam when this steam is in a saturation condition and between 95 and 120°C, which is normal.
- ✓ Concentration Factor
  It is the quotient resulting from the division of brine Recycle concentration by seawater concentration, both expressed in mg/L or ppm.

### 3.1.3. Vapor Compression

The Vapor Compression definition comprises two different processes: one compresses steam through the action of a motor driven mechanical compressor, known as Mechanical Vapor Compression (M.V.C.). The other procedure compresses steam by means of an ejector compressor, powered by medium pressure steam. This procedure is known as Thermal Vapor Compression (T.V.C.).

#### 3.1.3.1. Mechanical Vapor Compression

Let's start by explaining the Mechanical Vapor Compression process according to the diagram in Figure 3.3. In this type of plant there are three important sections: a motor-driven compressor, a single or multi-stage evaporator and a liquid/liquid heat exchanger.

Seawater is passed through the heat exchanger, where it is heated. It is then supplied to the entire cycle, into which it is mixed with a portion of brine, forming the feed; then, it is pumped to the evaporator and sprayed through the nozzles into the condenser tubes. This feed is heated until it reaches the saturation temperature corresponding to the pressure inside the evaporator and, as it continues to absorb heat, a part evaporates. The steam formed is passed through a demister and enters compressor suction, which compresses it until it reaches a higher pressure, becoming a superheated


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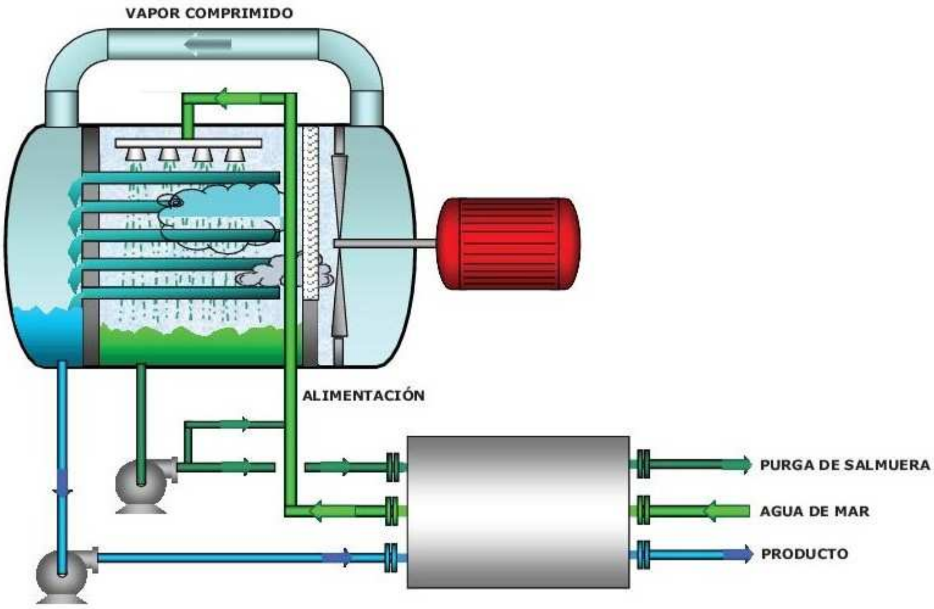
steam. This steam is introduced into the evaporator tubes, where it first loses its sensitive heat and then condenses, producing heat for the feed that is dripping down outside the tubes.

Figure 3.3 - Mechanical Vapor Compression Cycle Process

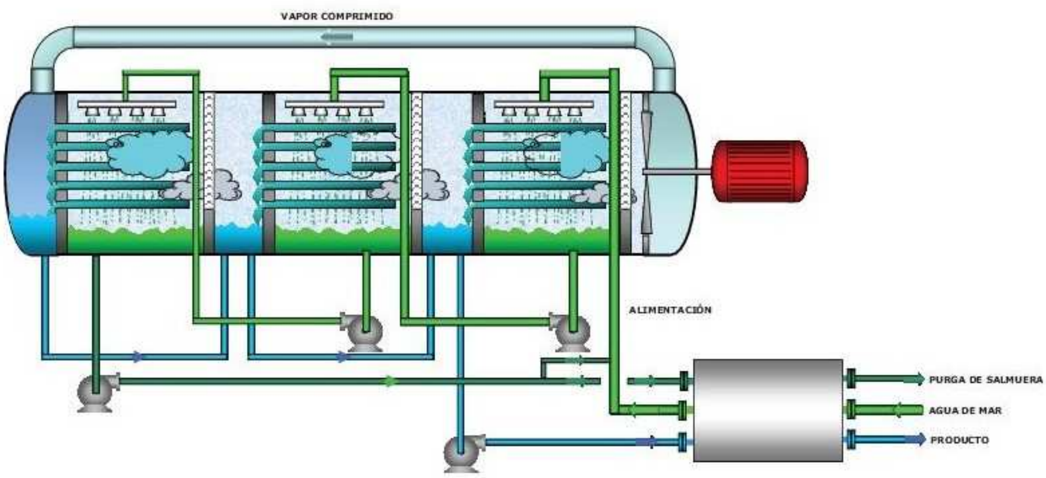



The product is extracted by a product pump, and, since it still carries sensitive heat, is cooled in the plate heat exchanger, heating the seawater incorporated into the cycle. The unevaporated intake water falls to the bottom of the evaporator, from where it is extracted by a pump, splitting into two streams: one that mixes with the collected seawater to form the feed, and the other, the brine purge needed to maintain the salt balance.

Since the purge still has sensitive heat, it is cooled in the plate exchanger, where it provides heat to the seawater entering the evaporator. The seawater is degassed before entering the cycle, and chemically treated to prevent scale and corrosion. There is also a vacuum equipment consisting of a vacuum pump to extract incondensable matter from inside the evaporator.

In this process it is possible to set up to three evaporators series, leaving the diagram as shown in Figure 3.4 below.

Figure 3.4 - Mechanical Vapor Compression Process Cycle (Multistage)



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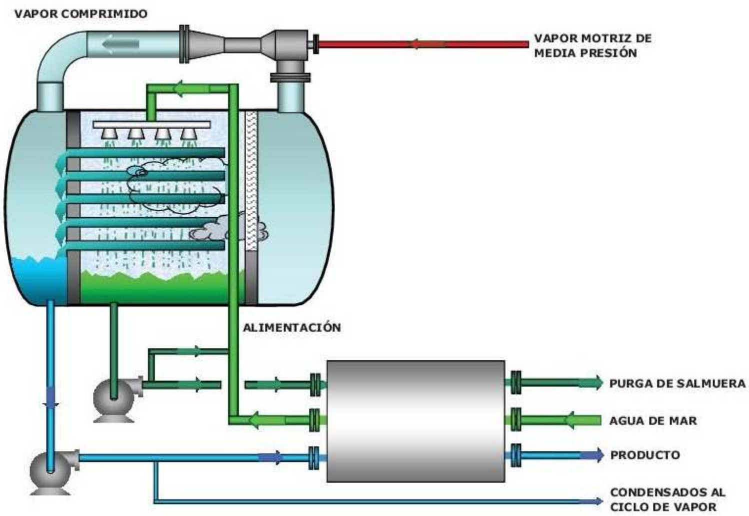
### 3.1.3.2. Thermal Vapor Compression

The Thermal Vapor Compression process is the same as the Mechanical Vapor Compression, in that it replaces the compressor with an ejector that works with external vapor, as can be seen in Figure 3.5. The most important difference between the two is that in TVC the external vapor is mixed in the vapor ejector and the vapor is produced inside the chamber; therefore, the product obtained must be divided into two streams: one that has the same flow weight as the motor vapor used, which is returned to the steam boiler (this stream is called Condensate) and the other part, which is the liquid product obtained.

Figure 3.5 – Thermal Vapor Compression Cycle Process




The characteristic parameters of Steam Compression are as follows:

- ✓ Compression ratio
  It is the ratio between compressor outlet pressure and interior evaporator pressure or the suction pressure. In these plants, the compression ratio is generally low, varying from 1.25 to 1.35, approximately.
- ✓ Concentration factor
  It is the number resulting from the division of brine purge and seawater concentrations, both expressed in mg/L or ppm.

## 3.1.4. Solar Distillation

Figure 3.6 shows a basic scheme of a Solar Distillation system. It is a low, fully enclosed "small pool" whose roof is composed of clear glass plates. The floor is made up of two layers: the first is a heat insulating material, and the second, placed above it, is a black surface that absorbs all radiation directed to it.


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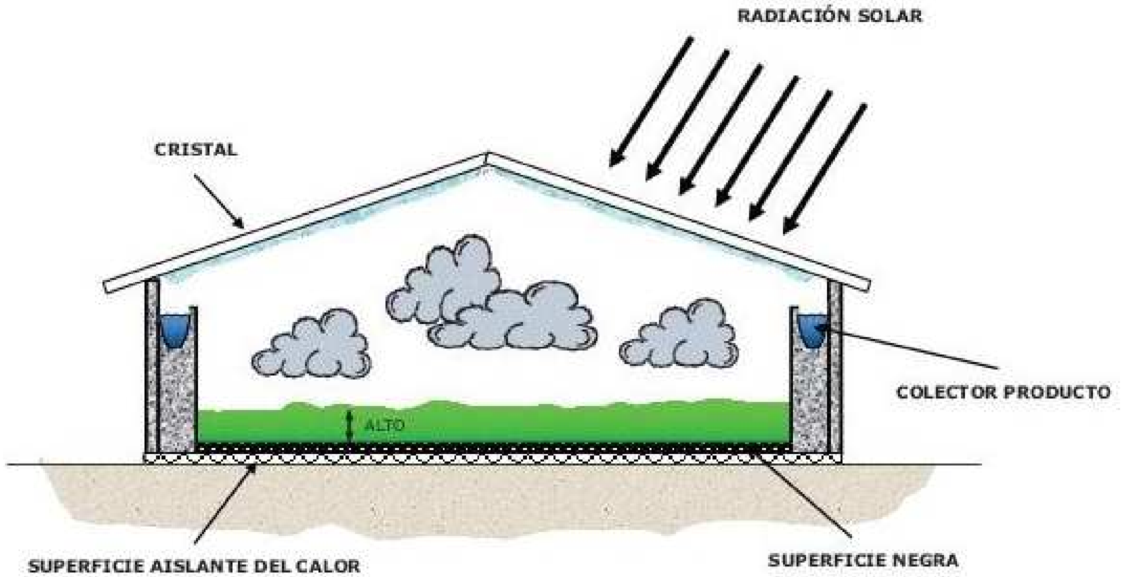
Figure 3.6 - Direct Solar Distillation Plant Diagram



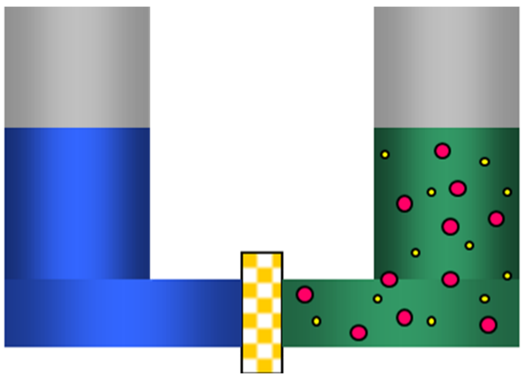

In this module, seawater is introduced in sufficient quantity to reach a height of 5 to 30 cm. Solar radiation moves through the glass, and is reflected by a small part of it; the rest reaches the seawater, where another portion is absorbed. The black surface captures the rest, and while it is heated, it heats the seawater, producing vapor. The mixture of vapor and hot air rises due to its lower density, and when it reaches the cooler glass, it condenses, and the condensed water slips down the inclined glass plane, being collected by the collectors located on the sides of the module from which it is extracted. Once the vapor has condensed on the glass surface and cooled the air, it descends again as its density increases, warming the water surface and saturating it with moisture, repeating the cycle.

Periodically, a purge is done to prevent salt sedimentation, which would result in decreased system performance. This process shows great variability in production capacity, depending on the time of day, seasons and weather conditions. This hinders its use in the management of large water requirement issues. However, it may be appropriate to provide drinking water in areas where there is no power source or the adequate means for the operation of a more complicated plant are not available. There are experimental plants of this type on Aldabra Island in the Indian Ocean, Chile, Patmos Island (Greece), Australia and the Pacific Islands.

### 3.1.5. Reverse Osmosis

The Reverse Osmosis process is explained in the Figures below, where two communicating vessels are shown separated by a semipermeable membrane, that is, a membrane that allows only the passage of water, not salts.

Figure 3.7 – Communication Vessels





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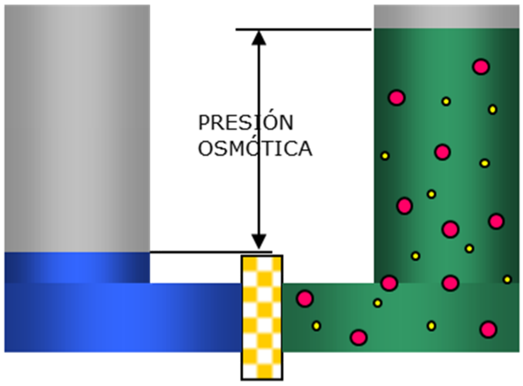
If we insert pure water in the glass on the left and a saline solution on the right, the osmosis phenomenon will occur. This phenomenon consists in the emergence of a pressure exercised by pure water molecules on the semipermeable membrane, through which they cross towards the saline, trying to reduce its concentration. Molecules from the saline solution also cross into pure water, but the quantity of pure water molecules that pass through the membrane is greater toward the saline solution. This is the osmosis process, and with it there is loss of pure water and an increased the amount of salt water. This happens until the water column between the two vessels is in a state where the liquid pressure on the saline side equals the osmotic pressure, leaving the vessels as shown in Figure 3.8, where the process is stalled.

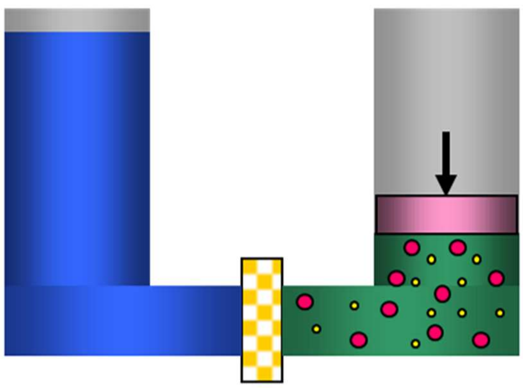
Figure 3.8 – Direct Osmosis




What really happens is that, once the osmotic and hydrostatic pressures on both sides of the membrane are equalized, the number of water molecules passing through it in one direction is equal to the number of molecules passing through it in the other, thus resulting in balance.

If in this same osmosis process, as shown in Figure 3.8, we push a plunger over the surface of the saline solution and exert mechanical pressure on it, when the liquid levels in both vessels are equal, the pressure exerted on the plunger will be equal to the osmotic pressure of the initial saline solution. If pressure is continuously increased, the equilibrium is reversed, and thus more water molecules will cross from the saline solution, the vessel on the right, to the pure water side, the vessel on the left, Figure 3.9. That is, pure water will be obtained from the saline solution. This process is known as reverse osmosis and is applied to desalinate brackish and marine waters.

Figure 3.9 – Reverse Osmosis



PRESIÓN EJERCIDA > QUE LA PRESIÓN OSMOSTICA

Figure 3.10 shows the commercial reverse osmosis (RO) process. It is a simplified diagram of a one-stage seawater RO plant with a pretreatment that consists of multimedia and cartridge filters. Seawater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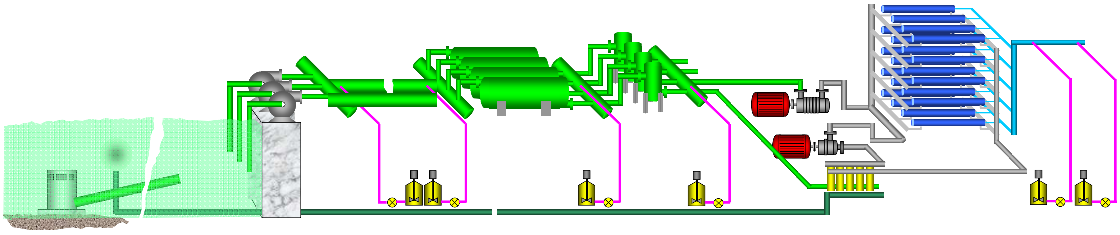
is pumped through an intake pump towards the multimedia filters, where suspended matter is eliminated; then, this filtered water is passed through the cartridge microfilters with a nominal pore size of less than 5 microns. This feed goes to a high-pressure pump, which is in charge of acting as a "piston" for the saline solution, providing the necessary pressure for the reverse osmosis process to occur.

The membrane working pressure for seawater is between 65 and 70 bar, considering that seawater has an osmotic pressure between 25 and 30 bar and pressure required for RO must be two and a half times the feed's osmotic pressure. The reason is that during the reverse osmosis process, seawater is concentrated inside the membranes, thus increasing their osmotic pressure. This means that brine disposal shall have a salt concentration almost twice as high as that of seawater, which implies osmotic pressures between 55 and 60 bar.

Figure 3.10 – General Diagram of an RO Plant



For brackish water, the working pressure depends on the concentration and type of dissolved salts, and the pressure at which the membranes should work will be studied in each case. In practice, it ranges from 8 to 30 bar.

An important parameter in the design of RO desalination plants is the so-called "conversion factor", the name given to the coefficient of division of permeate water flow (desalinated or osmotized water) by the feedwater flow to the membranes. The conversion factor depends on the type of dissolved salts, the pretreatment used and the amount of seawater that can be concentrated without precipitating salts.

The conversion factor of seawater is between 45 and 55%, that is, for every 100 $m^3$ of seawater introduced into the membranes, between 45 and 55 $m^3$ of permeate is obtained. However, for brackish water, this factor can reach up to 85%.

The brine exiting the membranes still has a lot of pressure, as loss within the pressure tubes containing the reverse osmosis membranes is small, between 2 and 3 bar.

To recover this energy, the brine is conducted to an energy recovery system. Currently, the brine energy recovery systems used in brackish and saltwater desalination plants are turbo-compressors and pressure exchange systems (PES). Other energy recovery systems, such as the inverted pump and the Pelton or Francis water turbine types are also found in some installations.

The brine energy recovery systems in RO plants take advantage of the pressure jump between brine pressure at the membrane outlets and the recovery system outlet pressure. With use of these energy recovery systems, the energy required to perform the RO process is reduced.

The permeate water leaving the membranes contains a certain amount of salts, since the salt rejection from the RO membranes is never 100%. Therefore, the permeate, depending on initial water concentration, conversion factor, water temperature, membrane type and design executed, shall have a different concentration. For seawater, permeate salinity is between 200 and 300 mg/L. To reduce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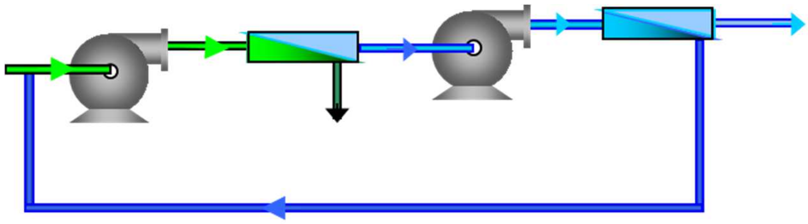
the permeate salt content, another osmosis pass must be included, then the process shall continue to two-stage plants.

Figure 3.11 - Two-stage RO Plant Diagram



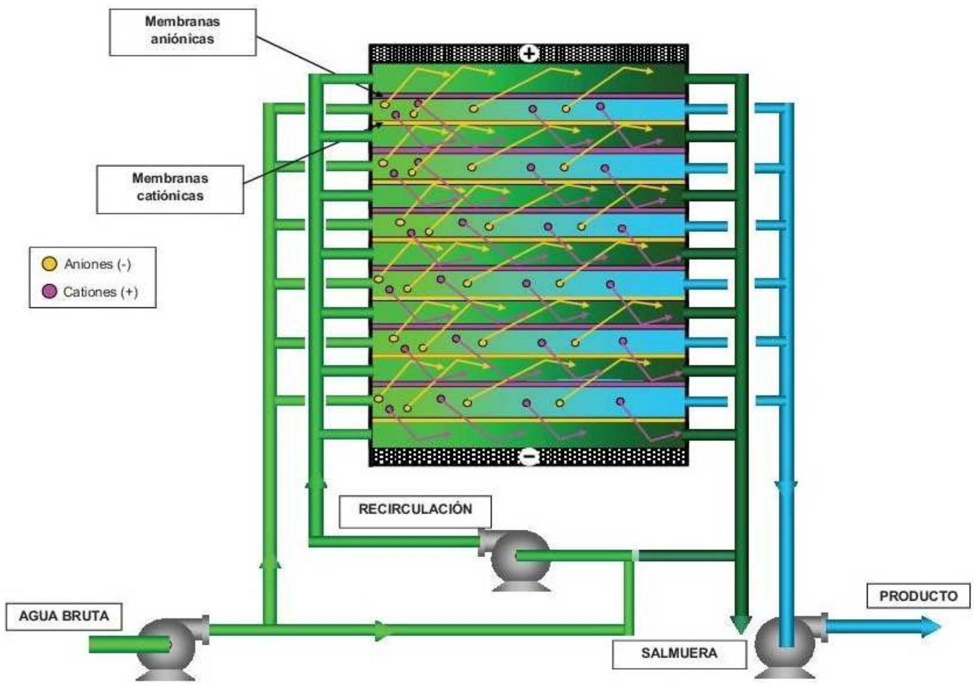
In Figure 3.11 we can see a simplified diagram of a double pass reverse osmosis (OI) plant. The permeate from the first pass is increased by pump pressure to 6 or 8 bar and introduced into brackish water type RO membranes. The permeate from this second pass will have a salt content of less than 10 mg/L. The conversion factor of the second pass is usually very high, around 90%. The discarded water from the second step is added to the raw feed water from the first step.

### 3.1.6. Electrodialysis

In electrodialysis, as opposed to RO, where water crosses the membranes leaving behind a salt-concentrated stream, what moves are the dissolved salt ions, which, when going through the membranes leave a salt-free water stream, as can be seen in Figure 3.12.

When salts dissolve in water, they dissociate to form ions. Ions are atomic or molecular particles with positive or negative electric charges. For example, common salt, sodium chloride, is ionized in positively charged sodium (Na +) ions (cation) and negatively charged chloride (Cl-) ions (anion).

Figure 3.12 – Electrodialysis Process




Under the effect of an electric field formed by a direct current, the ions will migrate in the following manner: positively charged cations (Na +, Ca2 +, Mg2 +, etc.) will move toward the negative pole, or cathode; the anions (Cl- , SO42-, CO3H-, etc.), negatively charged, will move to the positive pole, or anode, Figure 3.12.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To control ionic movement in an electrodialysis unit, laminar ion exchange membranes made from cation or anion exchange resins are used. They are called, respectively, cationic and anionic membranes. Cationic membranes have fixed negative charges in their structure (such as sulfonate groups), that repel anions. As a result, the cationic membranes (marked in yellow in Figure 3.12) will transfer cations, i.e., Na +, Ca2 +, Mg2 +, but not anions.

In a reciprocal manner, anionic membranes (marked in pink in Figure 3.12) have in their structure fixed positive charges (like quaternary ammonium ions), that repel cations and allow anion transfer, for example: $Cl^-$, $SO_4^{2-}$, $HCO_3^-$.

Figure 3.12 shows the classic layout of an electrodialysis plant or "stack", combining the elements described above (ions, selective anionic and cationic membranes and DC electric field) to achieve water demineralization and removed ion concentration in the water rejection stream.

The membranes are separated by a 1 mm spacer, then another separator is installed, followed by a membrane of the other type, and so on. In this manner, the set named ‘pair of cells’ is composed of the following:

- ✓ Cationic membrane.
- ✓ Cationic membrane spacer.
- ✓ Anionic membrane.
- ✓ Anionic membrane spacer.

Feed water containing the dissolved ions is pumped into the membrane set, circulating between the cationic and anionic membranes. The system described is the classic or unidirectional electrodialysis. It is known as unidirectional because the polarity does not change, so the ions always move in the same direction; thus, the water compartments’ characteristics remain unchanged, and the compartments will always be for demineralization or concentration.

The classic unidirectional electrodialysis (ED) system was the first process developed. However, the unidirectional ED process experiences a number of limitations that have been ameliorated with the conception of Electrodialysis Reversal (EDR), in which polarity changes from time to time and cells that were product become concentrated, and those that were concentrates become product.

### 3.1.6.1. Reverse Electrodialysis

The Reverse Electrodialysis mechanism differs from Unidirectional Electrodialysis (ED) in a simple, but very significant aspect. If a unidirectional electrodialysis system, as shown in Figure 3.12, is operated for a fixed and limited period of time (for example, 15 minutes), and then electric field polarity is reversed through an automated control system, operating it for an equal period of time in the opposite direction, and so on, the system will then become Reverse Electrodialysis (RED).

When the current is reversed, the compartment that was previously demineralized now becomes a concentrate, and vice-versa. Thus, it is necessary to change the valves through which they are fed and to collect these two flows shortly after current reversal. It is also necessary to deviate both flow rates for a period of 0.75 to 1.5 minutes to purge both compartments before the demineralized flow begins to manufacture the specified product.

Therefore, by operating for the same time period in both directions, the Reversible Electrodialysis system execution is achieved, which tends to eliminate insoluble or poorly soluble substances that would otherwise cover the membranes during the polarity reversal period.


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RED is the only desalination process capable of such inversion, due to two inherent system characteristics: a) RED membranes are symmetrical; they operate in the same way in both directions; and b) RED batteries have a symmetrical configuration, with concentrated and demineralized compartments.

For a RED unit to operate, a pressurized water supply is required, usually between 4 and 6 bar, as well as a direct current and a proper arrangement of the demineralization steps.

To save water, most of the water in the concentrate compartments is recirculated. The concentrate flow discarded is regulated by a control valve in the feed line, that controls water supply to the closed circuit loop that replaces an equal amount of concentrate water, that is moved to rejection, as show in Figure 3.12.

In summary, the RED process and system components are capable of long-term operation with water containing a wide variety of mineral, colloidal or microbiological components. Self-cleaning due to polarity reversal and membrane stability combine to provide a long-lasting service.

#### 3.1.6.2. Important Aspects in ED and RED

Electrodialysis is a process that can only be used in brackish water with a salt concentration lower than 8,000 mg/L. Through controlled concentrate flow recirculation and other means, up to 90% of the feed water can be recovered as product.

Electricity consumption can be roughly calculated using a value of 0.5 Kwh per cubic meter of pumping product, plus 0.5 Kwh per cubic meter per 1,000 ppm of eliminated salts.

Pretreatment is generally not necessary, as the RED system can treat water with a Langelier index of +2.2 and temperatures up to 45°C without any special care. Pretreatment is recommended when iron exceeds 0.3 ppm, and manganese and hydrogen sulfide exceed 0.1 ppm. Silica does not interfere with the process because is not ionized, and therefore it does not eliminate or limit water recovery. RED units are able to operate for a long time with water with a 5-minute SDI of approximately 15CHEMICA, thus minimizing filter use. But all the non-ionized and suspended material contained in raw water passes on to the product, such as bacteria, viruses, etc.

An EDR system does not require chemicals under normal operating conditions, except in special high-recovery situations and in the presence of calcium sulfate or calcium bicarbonates. EDR systems can tolerate calcium sulfate saturation rates of up to 175% in concentrate flow without chemical injections. The addition of antifouling and/or sulfuric acid allows calcium sulfate saturation rates of up to 400%. The chemicals are also required for periodic membrane cleaning. Battery membranes can be cleaned in three different ways:

- ✓ Continuously, through polarity reversal
- ✓ By periodic chemical cleaning (CIP System)
- ✓ Manually: disassemble and clean membranes by mechanical manual procedures.

EDR membranes are 0.5 mm wide homogeneous reinforced polymer sheets, with transfer anions and cations fixed in certain positions and excellent stability against chemicals and temperature. Resistant to continuous pH values of 1 to 10 and 0.3 ppm free chlorine, they can withstand large amounts of it during short cleaning periods. The membranes can function at temperatures up to 55°C.

### 3.1.7. Nanofiltration



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Nanofiltration (NF), a process located between ultrafiltration (UF) and reverse osmosis, uses semipermeable membranes with an approximate pore size between 0.0001 and 0.001 microns, that is, less than one nanometer, rejecting organic molecules molecular weight greater than 200 Daltons.

Nanofiltration removes water salts and involves chemical and physical processes, being therefore considered a desalination process, unlike Ultrafiltration (UF), whose principle is physical separation. In UF, it is membrane pore size that determines to which extent dissolved solids, turbidity and microorganisms are eliminated. UF is used to remove 0.001 - 0.1 μm particles from water, as well as viruses.

As a distinctive feature of NF compared to the RO process, monovalent ions have a rejection rate between 30 and 60%, and divalent ions between 90 and 98%. This difference in rejection rates functions at a lower pressure than in RO (4 to 12 bar, depending on water types).

NF membranes are generally spiral wound and generally composed of polyamide as an active layer, and polysulfone and polyester as support layers, when the objective is to eliminate divalent salts. There are other nanofiltration membranes on the market with different active layers, such as polyvinyl alcohol and sulfonated polysulfone, spiral wound configuration or hollow fiber.

Nanofiltration is a very similar process to RO. Just like RO, it requires contributing water pretreatment to prevent membrane clogging by colloidal particles and chemical precipitation, which causes frequent interruptions for cleaning. The operating scheme is exactly the same as that of a reverse osmosis plant; the difference between the two processes is that, while reverse osmosis rejects almost all salts in equal percentage, nanofiltration fundamentally rejects divalent ions, and, to a lesser extent, monovalent. The advantage of nanofiltration over RO is that it requires less energy per cubic meter produced.

Nanofiltration is applied to brackish water, generally for one or more of the following purposes:

- ✓ The elimination of certain divalent salts.
- ✓ Water hardness reduction.
- ✓ To reduce the content of anthropogenic organic matter, such as pesticides and naturally occurring organic matter (humic acids).
- ✓ As a pretreatment technology in evaporation desalination plants, with the objective of reducing calcium sulfate content, to allow the increase of maximum operating temperature and prevent precipitation of these salts.

## 3.2. Comparison of Technologies

The use of the desalination processes presented in the previous items requires the use of adequate infrastructures for the intake, pretreatment, removal of dissolved salts, post-treatment and reject disposal. In general, the intake infrastructure will be similar for any of the technologies contemplated, with the most relevant aspects for technology selection being the efficiency in converting saline water to drinking water, specific energy consumption, final cost of production and associated environmental impacts.

For comparison purposes, Table 3.2 presents data on conversion efficiency, energy consumption and the estimated cost of water production by evaporative desalination and reverse osmosis (Voutchkov, 2013 and Watson, Morin and Henthorne, 2003). For the thermal processes, an external heat source is required, usually from a thermal power plant, which, when unavailable at low cost or free of charge, makes such processes unfeasible.


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When analyzing these data, it can be verified that the reverse osmosis desalination process presents a lower energy consumption and higher water conversion, while it has a production cost range similar to the other processes, with a lower limit. It can be reiterated that the use of the energy recovery system results in an even lower cost range for the reverse osmosis system.

Table 3.2 – Seawater Desalination Processes Comparison

| **Parameter** | **Thermal Processes** | | | **Reverse Osmosis** |
|---|---|---|---|---|
| | **Multiple Stages with Vapor Expansion** | **Multiple Effects** | **Vapor Compression** | |
| Conversion Factor (Drinking Water/Feed) | 0.10 – 0.20 | 0.20 – 0.35 | 0.40 | 0.45–0.55 |
| Thermal Energy Consumption Equivalent (kWh/m³) | 9.5 – 11.0 | 4.5 – 6.0 | NA | NA |
| Electrical Energy Consumption (kWh/m³) | 3.2 – 4.0 | 1.2 – 1.8 | 8.0 – 12.0 | 2.5 – 4.0 |
| Total Energy Consumption (kWh/m³) | 12.7 – 15.0 | 5.7 – 7.8 | 8.0 – 12.0 | 2.5 – 4.0 |
| Water Production Cost (US$/m³)[a] | 0.90 – 4.00 | 0.70 – 3.50 | 1.00 – 3.50 | 0.50–3.00 |

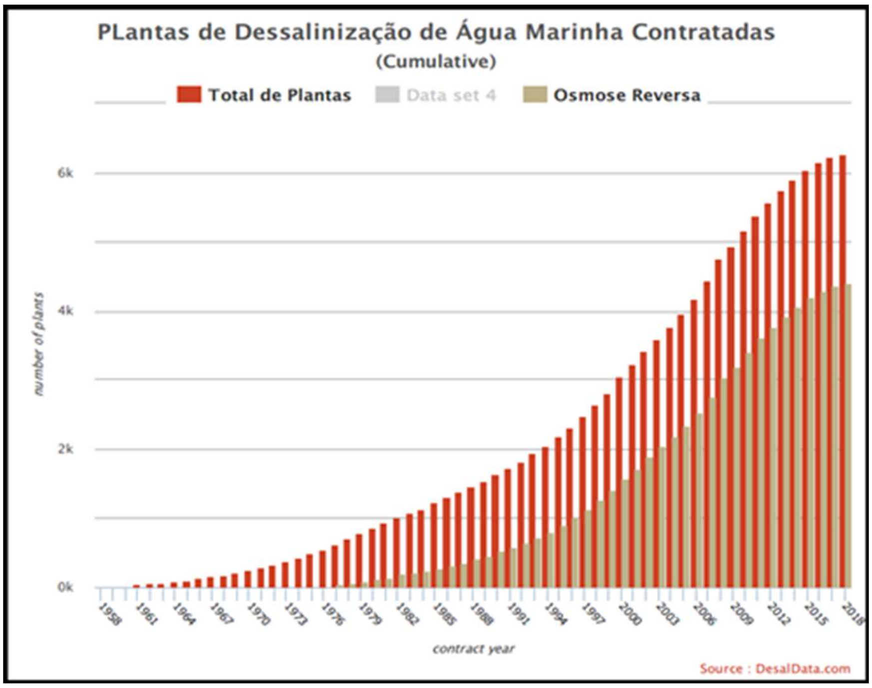
NA – Not Applicable

a – Based on year 2013.

With basis on the information presented and considering that commercially there would be no other viable process or technology available for the flow rate required for this project ($1m^3/s$), it is substantiated that the reverse osmosis desalination is the most suitable process for this case.

This conclusion is confirmed when assessing the historical evolution of the amount of plants contracted up to 2018, recorded in the worldwide DESALDATA database (Figure 3.13). In there, it can be observed that most plants built until that year use reverse osmosis technology.

Figure 3.13 – Amount of seawater desalination plants contracted until 2018.




Source: www.dessaldata.com

In terms of quantity, there currently are 55 seawater reverse osmosis desalination plants destined for human consumption in operation, with capacity equal to or greater than the defined flow rate for the present project ($1m^3/s$), which are distributed according to following chart.



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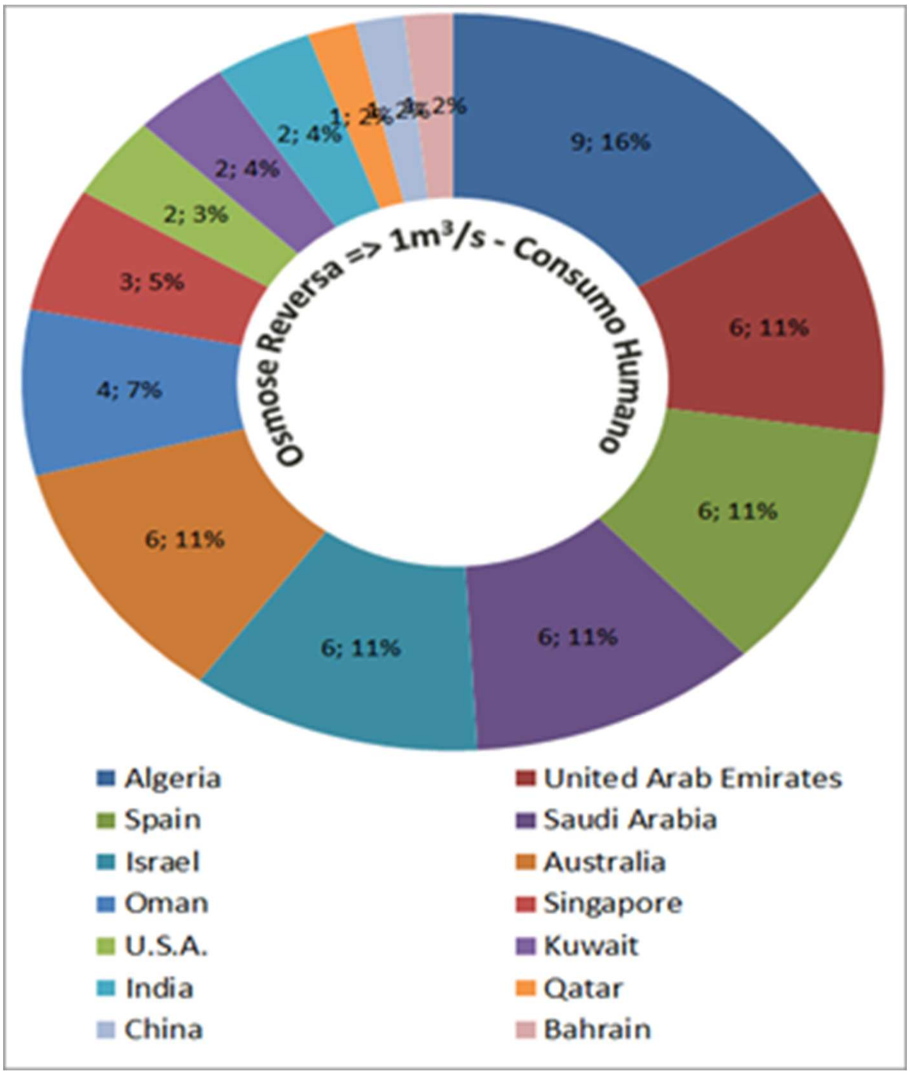
Figure 3.14 – Amount of reverse osmosis desalination plants for human consumption with flow rate greater than $1m^3/s$, in operation until 2019.




Source: [www.dessaldata.com](http://www.dessaldata.com)



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# 4. RO Plant Processes and Systems

In general, the processes and systems in which an RO desalination plant can be divided are the following:

- ✓ Intake
- ✓ Chemical Pretreatment
- ✓ Physical Pretreatment
- ✓ Reverse Osmosis Process
- ✓ Process Centrifugal Pumps
- ✓ Brine Energy Recovery
- ✓ Post-treatment
- ✓ Storage and impulsion for product water
- ✓ Brine Disposal
- ✓ Auxiliary Services
- ✓ Instrumentation and control
- ✓ Electrical System

## 4.1. Intake

The main objective of a basin is to achieve the raw water flow needed for the desalination process and while not affecting or minimally affecting the marine environment. In distillation processes, this is practically the only objective, since they are almost insensitive to differences in the quality of the raw water collected. However, for reverse osmosis, besides the main objective, it is specified that the water intake:

- ✓ Contains no suspended matter or as little as possible of it;
- ✓ Does not contain hydrocarbons, oils or fats
- ✓ Contains no fish, bacteria, algae, microalgae or plankton, or that their content is as small as possible
- ✓ Contains no dissolved organic matter (ex.: BOD5, COD, TOC) or as little of it as possible
- ✓ Does not contain heavy metals, other than those naturally dissolved in raw water, from industrial or other activities.
- ✓ Is not affected by natural phenomena, like red tides;
- ✓ Has the smallest temperature variation possible between summer and winter.

For the design and operation of seawater RO desalination plants, the intake performed is very important.

### 4.1.1. Types of intake

Having to decide on one type of intake is an issue that usually arises in seawater desalination plants, because when it comes to desalinating brackish water, absorption is usually defined by the source used. Brackish water sources are, in most cases, wells, although sometimes brackish water from reservoirs or rivers is used.

On the other hand, for a seawater desalination plant, the type of basin is usually not defined and is decided according to the size of the facility and other conditions explained below.


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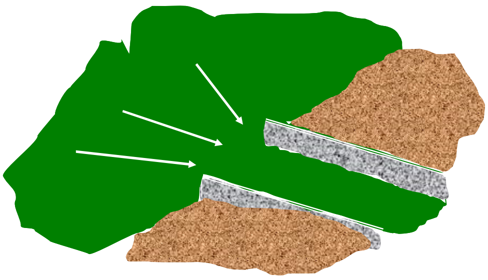
Possible solutions for seawater intake can be broadly divided into "Open Intake" or "Well Intake". The best option, in terms of water quality, is typically the well intake, since water from wells is naturally filtered through the soil. However, there are situations where well intake is not an option. Open and well intake are divided into different types.

#### 4.1.1.1. Open Intake:

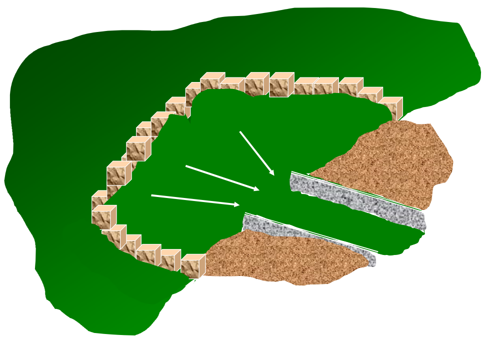
**Open intake:** intake happens directly when a channel is built on the coast to allow direct seawater entry into the intake pumps' location. The main advantage of this acquisition is that it is inexpensive construction work, but the main disadvantage is that the water quality is very poor, being always subjected to all kinds of variations that the sea may cause: waves, the entrance of suspended and floating matter, fish, fuel, etc.

Figure 4.1 – Open Intake



**Open Intake Basin with Breakwater:** It is a direct intake process in which, to try to solve some of its complications, a breakwater is built. This is to prevent the direct effect of the swell on the inlet, and the entrance of floating matter, creating a quiet area where partial decantation of suspended matter can occur. It also helps prevent the entrance of fish. However, to solve some of these inherent complications, others occur. For example, the settling area becomes a fish farm, since the entry of eggs and plankton into a calm water site, well irradiated by the sun, make ideal conditions for the growth of fish and bacteria, with consequent problems for desalination processes.

Figure 4.2 – Open Intake with Breakwater



**Deep Intake:** deep intake is performed through an intake tower located in areas where bathymetry is at least 20 m. Such a site is usually far from the coast, depending on the seabed slope, between 200 and 1000 m. The water intake obtained by the Tower is carried to the shore through a pipe, and this pipe is generally large in diameter for two fundamental reasons: the first is that intake speed is not very high, avoiding a strong current that may attract fish; and the second is for divers to pass through to perform tube cleaning and maintenance. The intake tower is designed to prevent the entrance of sand moved by the waves, seawater floating matter, hydrocarbons, oils, fats, fish and the like.



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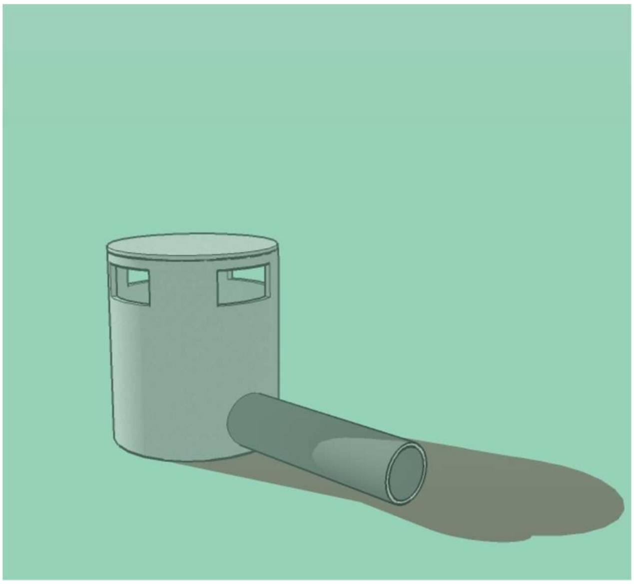
The tower is similar to the one shown in Figure 4.3; thus, the seawater inlet windows are far from the seabed where the sand is. They are also situated deep enough in relation to the surface to prevent floating matter from entering, such as matter that can be thrown into the sea by boats or any other source. The entrance speed through the windows is also very slow to prevent the creation of currents that attract fish. This system does not solve all problems, it but minimizes them and is currently the most used for open intake. The main problem is the cost and difficulties of maritime construction work.

Figure 4.3 – Intake Through an Intake Tower



#### 4.1.1.2. Well Intake

This type of capture will depend solely on the geological characteristics of the terrain, that is, the transmissivity coefficient of the layers that make up the geological structure of the coast, at the site where seawater intake is to be performed. Therefore, the type of well depends on the type of terrain, which can be:

**Shallow well.** This type of well is only possible if the soil is consolidated and shows high transmissivity, which is not very common. It was built at Lanzarote Island, where the fractured basalt allows excavation near the sea, with almost vertical walls that filter a large amount of water. Only suction pumps must be place on this well. The water is of great quality, with no suspended matter and very cheap acquisition. The problem is that this solution is usually impossible.



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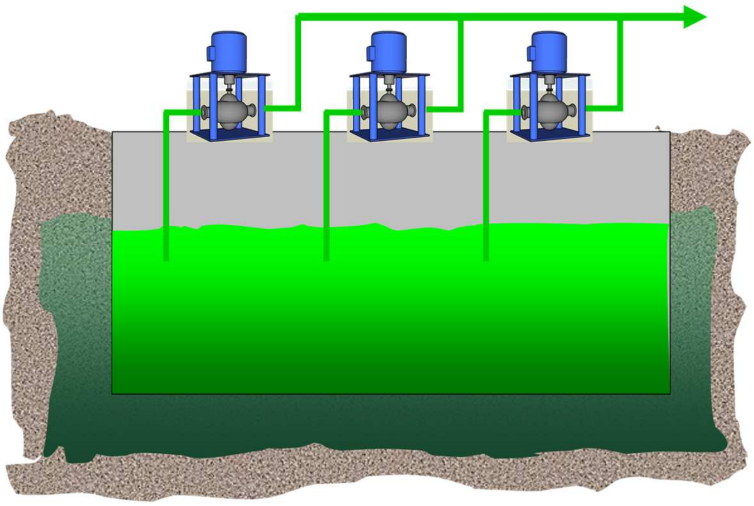
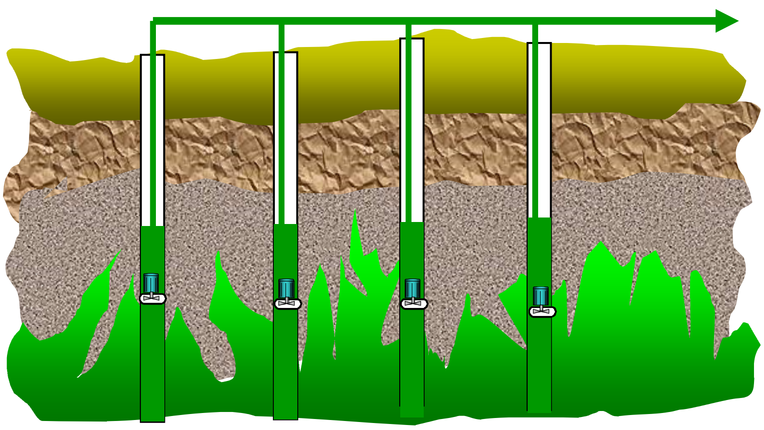
Figure 4.4 – Shallow Well Intake



**Vertical Beach Wells / Boreholes.** This type of intake can be performed when the terrain has good transmissivity. It consists of the construction of vertical boreholes with depths between 50 and 100 m, which cross permeable layers and normally allow intake of about 100 L/s. To prevent collapse, perforated PVC pipes or similar materials are introduced. A submerged pump is installed in each well that sends seawater to the plant.

Figure 4.5 - Borehole Well Intake



**Improved Wells.** When the objective is to capture large amounts of seawater for a large plant, boreholes can be inefficient and complicated due to the large number of wells that may need to be installed. For this reason, we have opted for improved wells, so that each one can provide more water flow, therefore reducing the number of wells required. For this, larger diameter wells with horizontal boreholes shall be constructed to allow greater flow. They represent Ranning well variants. Construction techniques are improving a lot currently; thus, unless land is very impermeable, it is possible to provide this type of intake for medium-sized plants.

## 4.2. Chemical Pretreatment

Chemical pretreatment of sea or brackish water has many objectives:

- ✓ To adapt water chemical characteristics to process requirements.
- ✓ To contribute to the chemical precipitation of unwanted salts before they reach the membranes.



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- ✓ To help in the elimination of suspended substances by improving the performance of physical treatments.
- ✓ Disinfection
- ✓ To avoid salt precipitation inside the membranes

The need for each previous action is determined by the quality of brackish or sea water collected, not necessarily of obligatory use in most cases.

To perform the aforementioned actions in a RO desalination plant, the following reagents are commonly used:

- ✓ To adjust pH: sulfuric acid, sodium hydroxide
- ✓ For disinfection: sodium hypochlorite
- ✓ To reduce residual chlorine: sodium bisulfite, sodium metabisulphite
- ✓ Coagulation: ferric chloride
- ✓ Flocculation: polyelectrolyte
- ✓ Inhibition of salt precipitation: dispersants

In plants, dosing systems shall be installed for the use of each planned chemical.

## 4.3. Physical Pretreatment

The Physical pretreatment is the group of processes included in the project to eliminate all undissolved substances in raw water, such as colloids, hydrocarbons, microalgae, suspended matter or floating materials through physical processes. Sometimes, physical and chemical pretreatments are combined to achieve the goal. For example, coagulants are added in filtration to coagulate suspended matter, making it more easily retainable.

The most common physical pretreatment operations are:

- ✓ Raw water prefiltration: rails, screen filters and self-cleaning filters;
- ✓ Flash mixing
- ✓ Flocculation
- ✓ Decantation
- ✓ Flotation
- ✓ Filtration in all its variants: multimedia (typically sand and anthracite), pre-coating, floating bed and cartridge filters.
- ✓ Ultrafiltration

The use of one or more physical pretreatments is determined by intake water characteristics and pretreated water (water before entering RO membranes) requirements. If a good preliminary study of the intake area and a correct basin project of the basin are performed, a complicated pretreatment should not be necessary. Therefore, a plant's "Project" begins with the election of a type of intake and its design.

In general, for seawater, it is recommended to avoid processes that are performed in open or covered gravity chambers and consider where aeration is performed, such as: gravity filters, chamber coagulation or flocculation, decantation, DAF. If it is imperative, they can be installed, but it is generally preferable to avoid these processes because the following usually happens in these chambers:

- ✓ Materials entering the system, such as sand, paper, plastic, etc., due to the wind or human



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action.

- ✓ Aeration of intake water through overflow when it passes from one chamber to another, for example, or when washing with air or creating bubbles for flotation.
- ✓ Exposure to solar radiation, which can be happen directly or through windows.

The first event directly contaminates water and, as a consequence of the last two events, bacterial growth in seawater is favored. It contains bacteria and food, which along with aeration and solar radiation exposure, facilitates the growth of bacterial colonies, viruses, microalgae, etc. The raw water reaching the membranes will contain more living matter than the raw water initially captured, and this will result in biofouling problems on the RO membranes.

### 4.3.1. Prefiltration

Pre-filtration equipment is installed before the plant's raw water pumps, usually consisting of rails and / or rotary screens or self-cleaning filters.

The installation of this equipment must be done including isolation gates and spare equipment to perform the washing and maintenance tasks without stopping the plant.

### 4.3.2. Coagulation

Coagulation is determined by the amount of coagulable material in the raw water to be coagulated; the resulting clots are then decanted or retained in filtration processes.

Coagulation can be done with slow agitator chambers or in-line with static mixers installed in the pipe lines. Whenever possible, as already mentioned, the use of static mixers and tube coagulation is preferable, as this type of coagulation is a closed process.

### 4.3.3. Flash mixing - flocculation

The need to install the flash mix and flocculation is determined by the amount of flocculable material in the raw water requiring flocculation, or because the raw water contains heavy metals that need to be precipitated, for example, through the addition of lime or polyelectrolyte.

Flash mixing is performed in chambers with rapid stirrers to mix the flocculant, and flocculation is performed in chambers with slow stirrers that facilitate flake formation without breaking them, so these flakes decant or float. If possible, online flocculation is recommended. If flash mixing and flocculation must be installed in atmospheric chambers, it is advisable that they are covered to at least reduce solar radiation exposure and possible entry of undesirable substances.

Besides, in the case of atmospheric chambers and to avoid breaking the flakes formed, the step to the next pretreatment stage, decantation or flotation, must be done by gravity, not by pumping water. The pumping would break the formed flakes, rendering the installation of a mixing and/or flocculation system useless.

### 4.3.4. Decantation

The decantation process is used when the suspended materials, clots or flakes formed are heavy enough so that at low speeds they can settle to the bottom of the settling basin, being extracted from time to time. The type of settling tank to be used can be of various shapes and models: square, circular, with a crane and scraper, sludge recirculation, etc.


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The decantation process is performed in atmospheric chambers which, as in Flash Mixing, Flocculation or Coagulation, should only be used when there is no other alternative, and should be covered to avoid, as much as possible, solar radiation and contamination by outside materials.

### 4.3.5. Dissolved Air Flotation – DAF

This separation process is performed by air flotation, and its name derives from its English acronym, DAF – Dissolved Air Flotation. It is used in cases where raw water contains lots of floating matter (hydrocarbons, oils or fats in a considerable amount) or when intense red tides are expected.

In these cases, a floater will be installed to eliminate as much of the mentioned material as possible before it engages in other operations, such as filtering, to stop them from overloading. The flotation process is achieved by introducing air into the floater, as very fine and well distributed bubbles. These bubbles attach to the flakes and help them float.

From time to time a scraper passes through the surface of the water and sends the floating material to a container, from which it is extracted by some screw pumps. Air is introduced by recirculating a portion of the floated water, into which air is injected in a pressurized tank (air balloon). Then, this water is injected into the raw water inlet all the way to the float through a special nozzle, depressurizing and releasing air bubbles that will make the flakes, hydrocarbons, oils and fats present in raw water float. The floating water is extracted from the bottom of the floater into a clear water tank, from where it is pumped for the next process.

If raw water contains hydrocarbons, oils, fats or floating matter in significant quantities, it is because the choice of intake area or basin design has failed. Only in the case of intense red tides throughout the possible intake area, which is not possible to avoid with deep intake technique, the use of DAF treatment is mandatory.

Therefore, if DAF installation happens as a consequence of hydrocarbons, oils and fats present, it is most appropriate and beneficial to project a deep intake in which these substances will not be collected or to change basin location.

These solutions are preferable to installing complex pretreatments that will increase investment and operational costs, in addition to creating a problem throughout the desalination plants.

If DAF installation is motivated by intense red tides, it is convenient to perform deep intake so that the cell concentration/ml is as low as possible. If the DAF is still necessary then, it is convenient to install a bypass, so that it can be out of service when there is no red tide.

In any case, if a DAF system is installed, it must be done inside a vessel, or at least covered to prevent the entry of material carried by the wind and solar radiation, as already mentioned.

### 4.3.6. Filtration

RO membrane manufacturers request a plug rate at the entrance of their membranes, the Silt Density Index (SDI), to be less than 5 over 15 minutes, 100% of the time. It is recommended to be less than 3.

For this reason, to install at least one filtration pre-treatment is almost inevitable, since almost no intake water has an SDI of less than 3, or even 5.


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Only in the event that building a well intake is possible, the raw water's SDI may be low, and even in this case, filtration is normally installed for safety. If the groundwater evolves over time, then filtration will be necessary.

Filtration can be done in one, two or more stages. The decision on the number of stages to be installed will depend on the amount of matter contained in the raw water. If this amount is too large and a single filtration stage is used in an attempt to remove it, the filters will get dirty very quickly, allowing no washing time. In this case, it is reasonable to remove the material in two stages, so that each one removes about 50% of the matter weight present.

If the amount of matter is small, it can be designed for a single stage of filtration in multimedia filters, usually sand and anthracite. If the quantity is greater, two stages can be installed.

The filter type can be open, also known as gravity, or closed, also called a pressure filter. Gravity filters require intermediate pumping, since the raw water pumped from the intake minimizes filter load. In addition, they are subject to the aforementioned problems caused by gravity chambers. For this reason, open filters must be installed in a closed building to avoid solar radiation, thus minimizing bacterial growth; however, exposure to the environment and aeration cannot avoided, even in this case.

There are other types of filters on the market in which the filter layer is continuously washed, like Dynasand or filters where the filter layer produces a dragging effect of suspended matter, etc. The use of these commercial models depends on experience, necessity and whether they have advantages over conventional filtration.

For the elimination of hydrocarbons, oils or fats, even if they have been placed in a previous pretreatment operation, it would be necessary to install an active carbon filter that guarantees their total elimination. The membranes cannot function in contact with these substances, not because they degrade them, but because the membranes are impervious to their passage. Thus, they can accumulate within the membranes' structure, which reduces their useful surface and, consequently, production. Active carbon can be used in granular or powdered form.

The installation of this type of pretreatment with activated carbon filters makes the operation much more complicated, and therefore large seawater desalination facilities where its use is feasible are not known. As was previously mentioned, the change is recommended in the project or intake area site.

In the event that the suspended matter is almost completely very small in size, < 30 microns, or the amount of particles in this range is high, the installation of a pre-layer filter can be studied. It would safely eliminate this issue, with a filter that can be regenerated in relatively easy manner. This pre-layer can be made of cellulose, diatoms or some material of this type. The cutting power is 15 microns. This type of filter is not currently used in large RO desalination plants.

### 4.3.7. Ultrafiltration

Microfiltration, a precursor to ultrafiltration, was the first membrane filtration technology. It has been used for more than two decades for the treatment, mainly of surface water, intended for human consumption, to eliminate and/or reduce protozoa such as *cryptosporidium* and giardia, turbidity, color, algae, bacteria and, in some cases, viruses linked to particulate matter, as an alternative to conventional physical and chemical processes.



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Ultrafiltration is a membrane process located between microfiltration and nanofiltration. Pore size is generally between 0.1 and 0.001 microns, although the most common way of expressing exclusion size in ultrafiltration is the molecular cut-off weight, expressed in Daltons. The generally accepted definition of molecular cut-off refers to the molecular weight of macromolecules such as dextran and globular proteins, among others, which are 90% retained by the ultrafiltration membrane.

Although the ultrafiltration membrane molecular sections are between 5,000 and 500,000 Daltons, they are typically used in pretreatments. Their molecular weight cut-off values range between 100,000 and 150,000 Daltons, equivalent to a pore size of approximately 0.025 microns, which eliminates macromolecules, proteins, viruses and colloidal silica, protozoa, such as cryptosporidium and giardia, as well as turbidity, color, algae and bacteria, like microfiltration membranes.

Most membranes are organic in nature, made of polymeric materials such as polysulfone, polyvinyl fluoride, polyamide, cellulose acetate, etc. Their configurations are generally made of capillary fibers in different diameters, in the form of flat membranes in a compact structure or cassette, and spiral winding as well. On the other hand, there are also inorganic, multi-channel ceramic membranes, based on zirconium oxide; they are more commonly used for industrial water treatments.

Ultrafiltration can be operated in two different hydraulic configurations, cross flow or direct flow. In the first, a tangential flow on the membrane surface, through concentrate recirculation, allows polarization reduction by the concentration of materials retained in it, which normally causes loss of flow and pressure. The collected water to be treated in the system compensates for ultra filtered water production and losses due to deconcentration purging. In the second, water flow on the membrane surface is direct or perpendicular, without any cross flow or recirculation. This system, also called blind or “dead end” configuration, allows significant energy savings. A short, automatic, sequential sweep allows treated water flow to remain stable.

Ultrafiltration use in desalination reverse osmosis pre-treatments allows fouling to be reduced, due to the high reduction of inorganic and organic colloids, responsible, for the most part, for the SDI 15 of the waters to be treated, whose size range is between 0.1 and 10 microns.

The ultrafiltration installations shall be basically composed of:

**Self-cleaning protection filters:** to remove large particles that can clog membrane capillary fibers; their slot size varies between 100 and 200 microns.

**UF racks:** contain modules with UF membranes.

**Sequence backwashing system:** usually, every 30 minutes of filtration and depending on the amount of material to be treated, a backwash is performed with ultra filtered water, and, for some manufacturers, with air.

**CEB - Chemically Enhanced Backwash:** it is usually performed every 12 hours, when side effects become more frequent. The same backwash equipment used and is composed of ultra filtered water, which is mixed with chemicals such as sodium hypochlorite, sodium hydroxide or sulfuric acid.

**Chemical cleaning system (CIP: *Cleaning in Place*):** it is usually performed every 30 days to recover the membrane performance if several backwashes have not been effective and CEB has not been done.

**Membrane integrity test:** to ensure the integrity of UF membranes, so they remain effective barriers.


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This ultrafiltration technology, similar to microfiltration, allows optimization of the membrane desalination project design by increasing its flow, that is, the liters per hour and per membrane square meter, by approximately 30%; it also provides water for reverse osmosis membranes with SDI 15 values generally less than 3.

Table 4.3 summarizes the results of a study on the elimination of different microorganisms by ultrafiltration.

Table 4.3 - Ultrafiltration Particle Elimination Assessment

| Microorganism | Concentration in collected water | Concentration in filtration | Elimination (Log) |
|---|---|---|---|
| *Giardia*, (cysts/L) | 2 E + 09 | <1 | >9 |
| Cryptosporidium, (cysts/L) | 1,5 E +09 | <1 | >8 |
| Bacteriophage MS2 UFP/L | 5 E +08 | 5 E +03 | >4,9 |

The bacteriophage MS2 virus has a size of 0.027 microns, which is smaller than the UF membrane pore size. However, high elimination is achieved, probably due to virus adsorption by suspended particles, membrane adsorption or secondary filtration due to membrane fouling. There is actually a tendency for improved MS2 removal as the membrane incrustation increases.

A very extended ultrafiltration configuration is online, that is, the ultra filtered water comes out under pressure from ultrafiltration membranes, directly feeding high pressure pumps leading to reverse osmosis membranes, without breaking the load in a storage tank. Since ultra filtered water is necessary for backwashing, a storage tank is installed, with a bypass, with an adequate volume to meet these needs. This configuration has advantages from an operational point of view.

There are RO membrane manufacturers that also make UF membranes, offering a complete package with guarantees that may be interesting, which is the case of Dow Chemical, Hydranautics and Toray.

Several ultrafiltration membrane manufacturers provide ultrafiltration system calculation programs for engineers and customers, for example: Pentair, Inge and Dow Chemical.

### 4.3.8. Cartridge Filtration

Cartridge filtration is a device generally required in reverse osmosis membrane manufacturers prerequisites, except when in-line ultrafiltration is installed as a pretreatment. To provide guarantees for RO membranes, manufacturers request the installation of these filters prior to high pressure pumping, whatever physical and chemical pretreatments are chosen, unless the previous pretreatment is the ultrafiltration line.

These filters consist of a container that contains the filter cartridges. There are many types of cartridges in the market, but as a common feature of them all, the length is always a multiple of 10", and, in most of them, cartridge diameter is 63 mm. The cutting power to be required is 10 microns absolute, with a Beta ratio of 5000. The Beta Ratio is the proportion of the number of particles larger than a certain size per volume unit of intake water divided by the number of particles larger than a certain size per unit volume in filter output water. It is a measure of filtration effectiveness; therefore, a Beta Ratio of 5000 means an efficiency of 100 x (1-1 / 5000) = 99.98%.

## 4.4. The Reverse Osmosis Process

### 4.4.1. RO membranes



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RO membranes are classified according to several aspects. These aspects are:

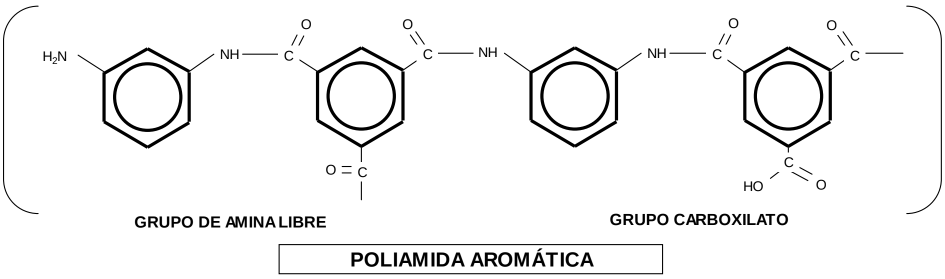
- ✓ The membrane's chemical structure, given by the different chemical compositions of commercial membranes on the market;
- ✓ The membrane's physical structure. The semi-permeable active membrane is very thin where the Reverse Osmosis phenomenon occurs. The rest of the membrane is structural. The way this set is composed and combined establishes the different physical structures of commercial membranes;
- ✓ The membrane's geometry. The membrane's commercial presentation establishes the different geometries existent on the market.

The aromatic polyamide structure is shown in the Figure below.

The most commonly used type, more competitive in price and performance are semipermeable membranes with aromatic polyamide chemical structure, with an asymmetric and composite physical structure and spiral wound geometric configuration.

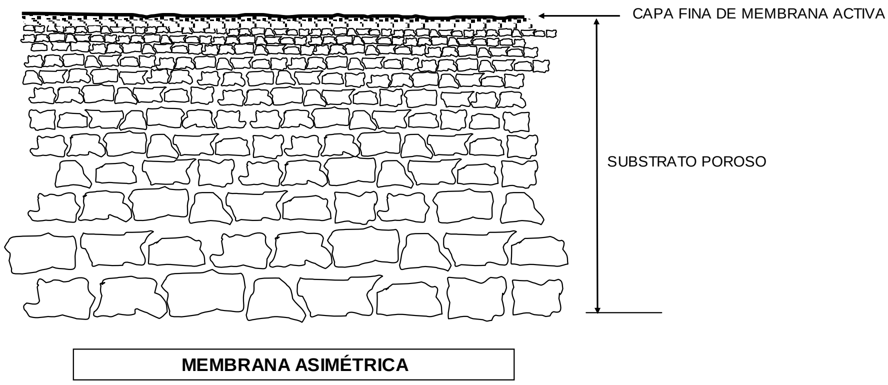
The structure of the aromatic polyamide is shown in the Figure below.

Figure 4.6 – Aromatic Polyamide Structure




Today, asymmetric membranes are used commercially. If the membrane is granted a cross section, two different layers shall be found: the semipermeable layer itself, which is where salt rejection occurs, and a porous layer that works as a substrate support, whose only mission is to promote mechanical resistance and let water pass through with its dissolved salts with the least pressure loss possible. See figure below:

Figure 4.7 – Asymmetric Membrane




This structure type is very convenient, because its active layer thickness is small, in the order of 1000 to 2000 Å; thus, the flow, which is inversely proportional to the thickness, can be very large. The rest of the membrane is the substrate, that works as physical support. The large pores on this layer make the water passage resistance small.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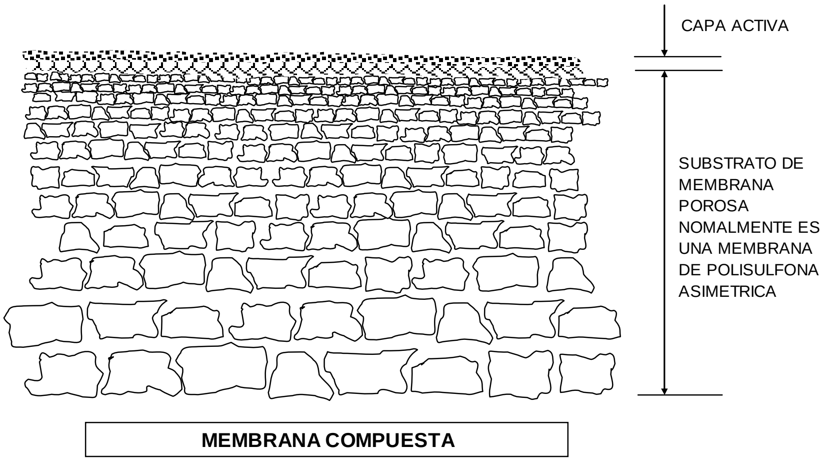
Polymer membranes do not allow the generation of an asymmetric structure with a single material, as happens with cellulose acetate membranes. Therefore, to obtain a membrane with these characteristics, two types of membranes are joined: one is the active layer of the chosen polymeric material and the other has an asymmetric porous structure, with increased porosity in one extremity and that acts as a physical support. These are the Composite Membranes. The set possibilities for the active and support layer are:

- ✓ By direct polymerization of the semipermeable polymer in the support membrane;
- ✓ Through chemical bonds that are established between the molecules of both layers. This is the crosslinked model.

The active layer deposited in the substrate is of 0.25 g/m$^2$. See the Figure below.

Figure 4.8 – Composite Membrane

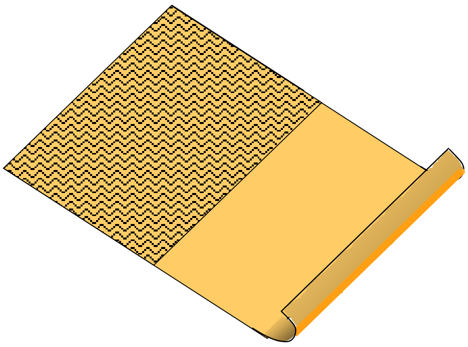



The geometry of spiral-wound membranes is explained below. To manufacture spiral-wound membranes, the membrane envelopes are formed by folding a flat membrane over itself and leaving a spacer inside, so that the inner walls remain separate and one side does not stick to the other.

This envelope has three of its four sides sealed. The open side of the membrane envelope is attached to a perforated tube and a spacer is placed between every two envelopes so that their sides are not in contact. This whole set is rolled up in the tube, thus generating a spiral-wound membrane. The described process is shown in the following figures.

- ✓ Flat membrane fold over itself, with the spacer placed between folds.

Figure 4.9 - Step 1. Spiral rolling (source: the author)



- ✓ Envelope formed with three sealed sides, with the interior spacer that unites the permeate water collection tube.
- ✓


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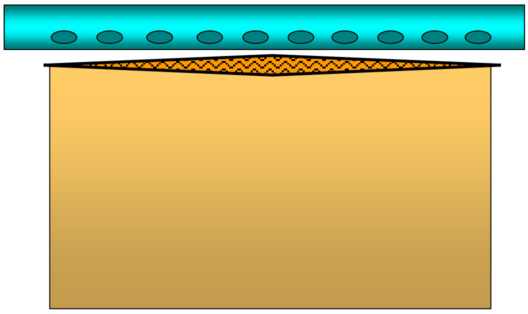
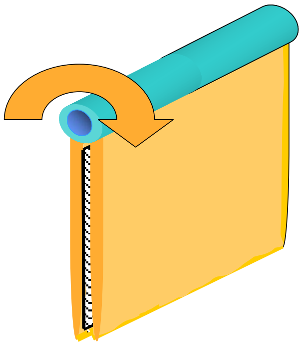
Figure 4.10 - Step 2. Spiral wounding (source: the author)



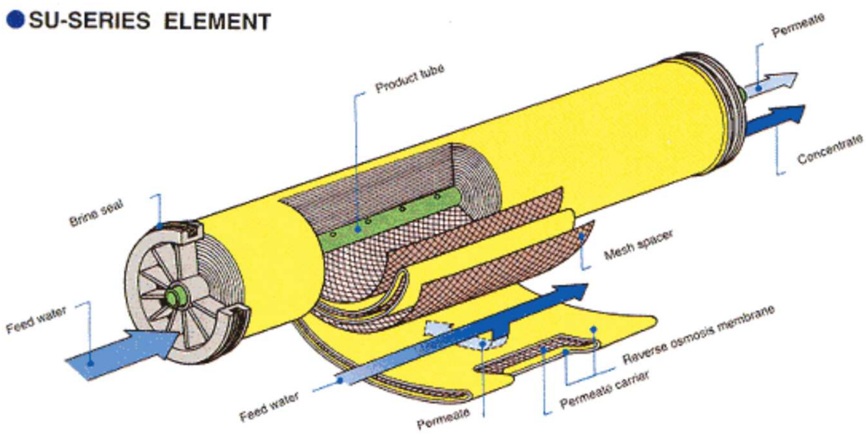
- ✓ The open side of the envelope sticks to the perforated tube, leaving the perforations on the envelope.

Figure 4.11 - Step 3. Spiral wounding (source: the author)



If several envelopes are made like the one previously mentioned, adhering to the tube for which the most longitudinal perforations were made, one per envelope, also putting some spacers between each envelope, finally, the whole set will be rolled into the tube, as shown in the Figure below. In this way, a spiral-wound membrane configuration is achieved.

Figure 4.12 – Spiral-wound Membrane (Toray courtesy)




This is the format used by the leading membrane manufacturers and is installed in most Reverse Osmosis plants in the world. The main reason for the widespread acceptance is a very compact configuration in which the ratio between $m^2$ of active surface per $m^3$ of membrane volume is high. In addition, all manufacturers have adopted equal dimensions for the membrane, which allows easy interchangeability.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The spiral-wound membranes have standard dimensions with a diameter between 2.5”, 4” and 8”, and a length of 1 meter. Currently there are also RO membranes with a 16-inch diameter and with a one-meter length, although only commercially installed in a few plants.

### 4.4.2. Pressure Tubes

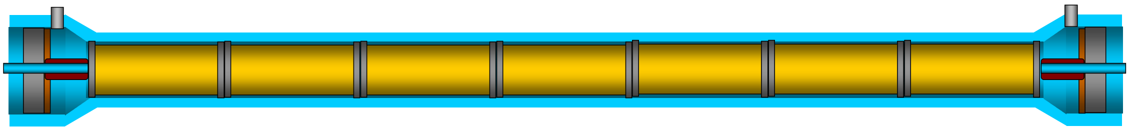
In a desalination plant, all membranes are installed inside a container that is able to withstand pressure and has inlet and outlet ports for different currents, raw water, brine and permeate water. This container is called a pressure tube. Pressure tube size and shape differ depending on the membrane’s physical configuration.

This section will refer exclusively to the pressure tubes used for spiral-wound membranes; they are the most common and offer more suppliers and tubes types that meet the objective, presenting interesting variations.

The pressure tubes are made of polyester reinforced with fiberglass and, to withstand high feed pressures, have an internal stainless steel mesh, which never comes into contact with the water. The pressure tube dimensions correspond to the membranes dimensions that they must contain. Thus, there are pressure tubes of 2.5”, 4” and 8” in diameter, with lengths varying from one meter, to contain one membrane, and up to eight meters, to contain up to eight membrane series. There are different manufacturers of these elements. Among the best known are Protec Arisawa, Bekaert, Bel Composite and the membrane manufacturers themselves.

When the membrane physical configuration is different than spiral-wound, the manufacturers themselves supply the membranes already installed in their pressure tubes. This is because, in other configurations, there is no standardization of membrane dimensions, and so that each manufacturer has its own special systems to process raw water, remove brine and the product, requiring a tube that is special and specific to each one of them, and these tube manufacturers cannot be found on the market.

Figure 4.13 – Pressure tube section with internal membranes



If a pressure tube is longitudinally sectioned, a head to connect the central membranes’ tube, where permeate water circulates with the outside can be observed in each extremity (see previous figure), as well as areas for raw water inlet at one end and brine discharge at the other. In the Figure, seven installed membranes can be seen in the tube, and between each of them there must be an interconnector or a connection system, so that there is continuity in the permeate central tube.

In the first pressure tubes, the raw water inlet and brine outlet were frontal, that is, they came out through ports located in the end head, as well as the permeate.



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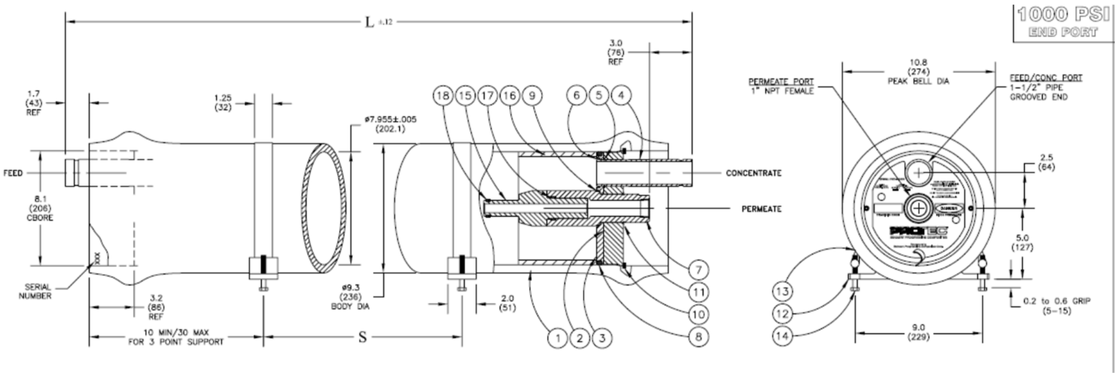
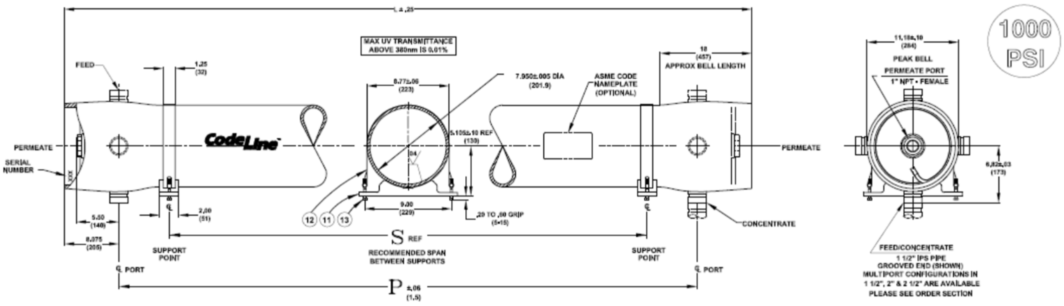
Figure 4.14 – Front Connection Pressure Vessel




In the next figure we can see a seawater pressure tube, with an outlet head and front inlet.

Subsequently, pressure tubes with a raw water inlet and side outlet of brine were invented, which offered advantages when designing the frame, reducing spaces and the need for interconnection tubes.

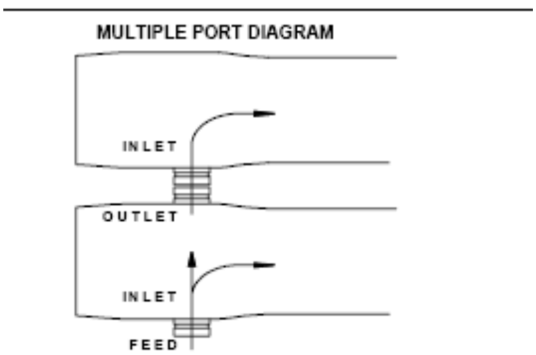
Figure 4.15 - Pressure Vessel with Lateral Connections (Source: CodeLine, Protec Arisawa courtesy)




In the previous Figure, a seawater pressure vessel with side and end ports can be found.

The last system developed is the connection of raw water inlet and brine outlet pipes, to a maximum of five pipes, which saves a lot of interconnection piping material, even though it implies rack construction to be made with great precision so that the pipes coincide and can be connected. The pipe heads acts as a distribution pipes for the following:

Figure 4.16 - Multiport Pressure Vessel (Source: Bekaert courtesy)




Another aspect of the pressure vessels that has been improved is its opening and closing system, in order to facilitate maintenance.



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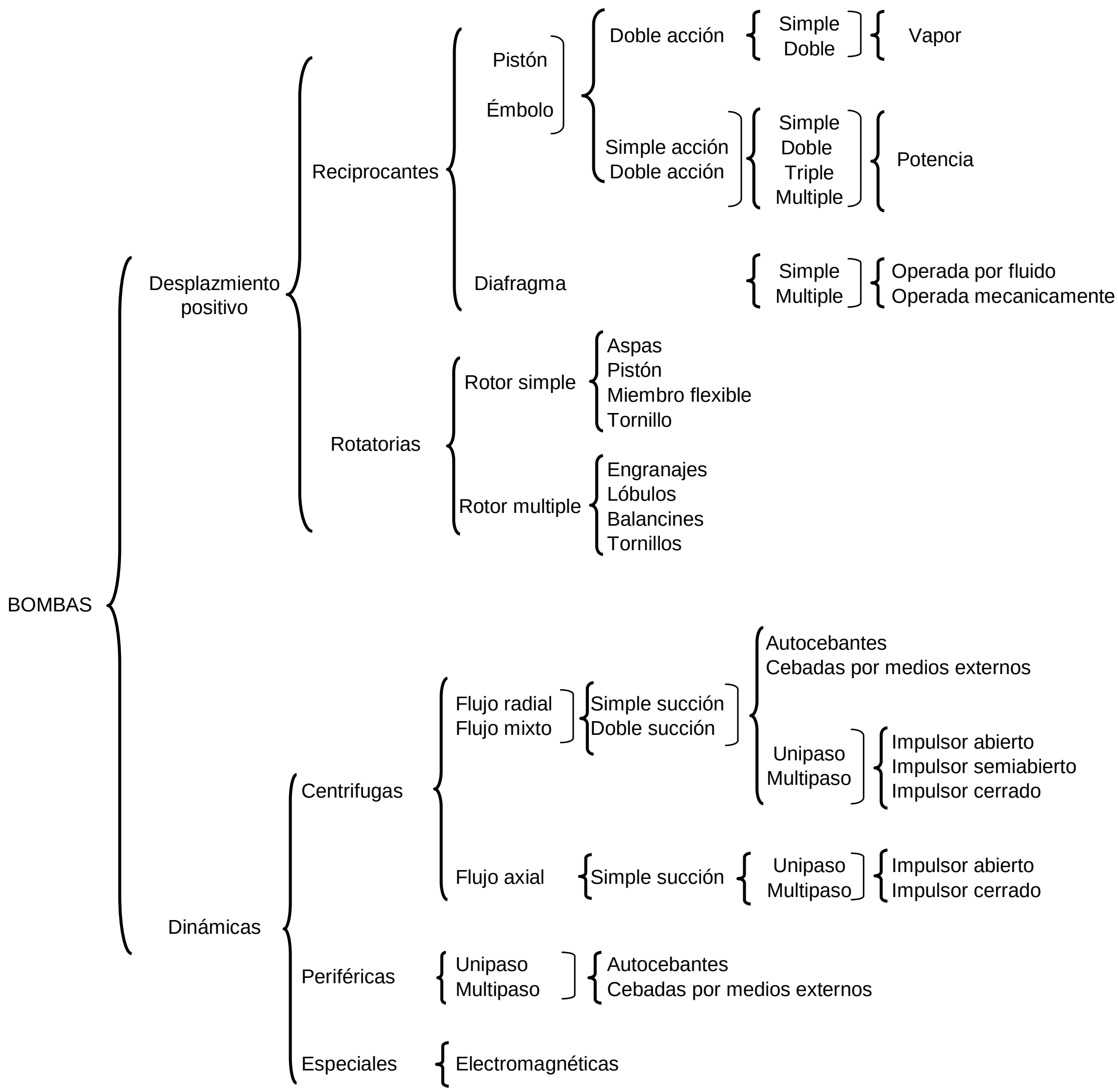
## 4.5. Process Centrifugal Pumps

The pumps are an essential part of a desalination system, so it is important to correctly assess and specify them so that the installation's operation meets the proposed Objectives. A general classification of the existing pump types is shown in the Figure below.

Figure 4.17 – Types of pumps




The most widely used pumps in large desalination plants are centrifugal pumps, which can be classified according to their configuration: horizontal, vertical and submerged pumps.

Likewise, multistage or horizontal multistage centrifugal pumps can be classified, depending on their construction: split-case or end-suction. Below are pump types classified according to different criteria.



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Table 4.4 – Centrifugal Pumps Classified According to Various Criteria

| CLASSIFICATION CRITERIA | TYPE OF PUMP | CHARACTERISTICS |
|---|---|---|
| Flow direction | Radial flow | The flow enters the impeller along the axis through the suction inlet and exits radially towards the shaft. Radial impellers that can be open, closed or semi-open are used. This type of pump is used to pump fluids to medium/high heights. In some types of suction pumps, the flow also exits radially. |
| | Mixed flow | The flow enters the impeller axially and exits in an intermediate manner, in a radial and axial direction. Radial impellers are used, and can be opened or closed. These pumps are used to direct the flow to medium heights. |
| | Axial flow | The fluid enters and leaves the impeller axially. They are used to pump large flows to low heights. |
| Impeller | Open impeller | The vanes are free on both sides and are held by a central ring through which the fluid enters. They perform poorly and are structurally weak, but are suitable to pump liquids with coarse suspended matter. |
| | Semi-open impeller | The vanes are free on one side and fixed to a plate on the other. They are suitable for pumping viscous fluids. They have greater resistance to abrasion than closed impellers and greater stability than open impellers. |
| | Closed impeller | The impeller is formed by two plates that surround the vanes. The flow moves from the eye, where it enters the rotor's periphery; this flow is better oriented and the performance is higher, but it works only for clean fluids. |
| Suction | Single suction | They have a single suction orifice |
| | Double suction | It has a single fluid inlet that is divided in two to move each flow to a rotor. Both impellers are installed in parallel, delivering the same pressure and working with half of the total pump flow. |
| Number of stages | Single stage or single step | They have a single impeller |
| | Multistage or multistep | They have two or more impellers working in series, so the discharge from one feeds the next. The total pressure height is the sum of the pressure heights gained in each of the impellers. They are used for high pressure pumping. |
| Pump position | Horizontal pumps | They are the most common and applicable to a multitude of services. |
| | Vertical pumps | Not submerged, used to save space. |
| | | The impellers are submerged, but the motor and couplings are above fluid level |
| | Submerged pumps | The pump and the motor are both submerged in the fluid. |

Considering all possible pump types, the following are generally used at the desalination plants:

- ✓ Positive displacement pump, alternative diaphragm, single or multiple, mechanically operated to dose chemicals.
- ✓ Pumps with positive displacement, rotary system, single rotor, screw, for sludge extraction from decanters or for the dosing of solid reagents, such as lime or calcium hydroxide, from storage silos.
- ✓ Centrifugal pumps (horizontal, vertical, submerged, split-case or end-suction for the pumping service needed to collect raw water.
- ✓ Centrifugal horizontal single stage pumps, single suction and radial impeller, for intermediate pumping services, backwash filter pumping, membrane chemical cleaning and displacement pumping, chemical transfer pumps, settled water pumps, effluent neutralization pumps, discharge pumps, recirculation pumps and second step feed pumps. They can also be used to


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conduct product water outdoors if discharge pressure is low.

4.6. Multistage horizontal centrifugal pumps with single suction and split-case or end-suction, for high-pressure pumping and product water boosting services, if discharge pressure is high.

## 4.7. Energy Recovery Systems

Energy recovery systems for brine have evolved over the years, increasing energy efficiency. The most common systems are the following:

- ✓ Inverted pump or Francis turbine
- ✓ Pelton Turbine
- ✓ Pressure Exchange System
- ✓ Turbocharger

### 4.7.1. Reverse Pump and Pelton Turbine

The reverse pump, which in fact is a Francis turbine, was the first system used to recover brine energy. Its yield is low, around 75%, and to avoid cavitation it is necessary to release some pressure (around 1 bar) at the brine outlet.

The Pelton Turbine, the next system used to recover energy, is more efficient than the Francis turbine (88%) and its brine discharge happens by gravity.

The inverted pump has been abandoned since the Pelton turbine began to be used, since the latter is more suitable in terms of recovery performance and investment costs.

The manner in which both systems supply energy is displayed in Figure 4.18.

Figure 4.18 - Brine Energy Recovery System by Turbine in an RO Plant


In both cases, the electric motor has a double shaft that, which on the one hand, joins the high-pressure pump that feeds the seawater sent to the membranes, and the other end, the energy recovery turbine. With this configuration, the energy that the motor must supply is the difference between the energy demanded by the high-pressure pump and the energy recovered by the turbine.

### 4.7.2. Pressure Exchange Systems

Currently, new energy recovery systems, the "Pressure Exchange Systems" (PES), have emerged. To understand in a simple manner how this equipment works, it can be said that just like heat exchangers exchange heat between two flows, Pressure Exchange Systems exchanges pressure between two streams of water. On the one hand, the brine enters at high pressure; on the other, seawater comes in at low pressure. The pressures are exchanged, and the brine exits at low pressure, and seawater at high pressure. The pressure is exchanged through contact with both flows. In this way, the brine pressurizes the entering seawater. Currently, there are PES manufacturers with proven solvency for brine energy recovery in RO desalination plants.

The system configuration is different from that of Francis or Pelton turbines, but the overall efficiency of energy recovery is greater. The setting is shown in the Figure below.


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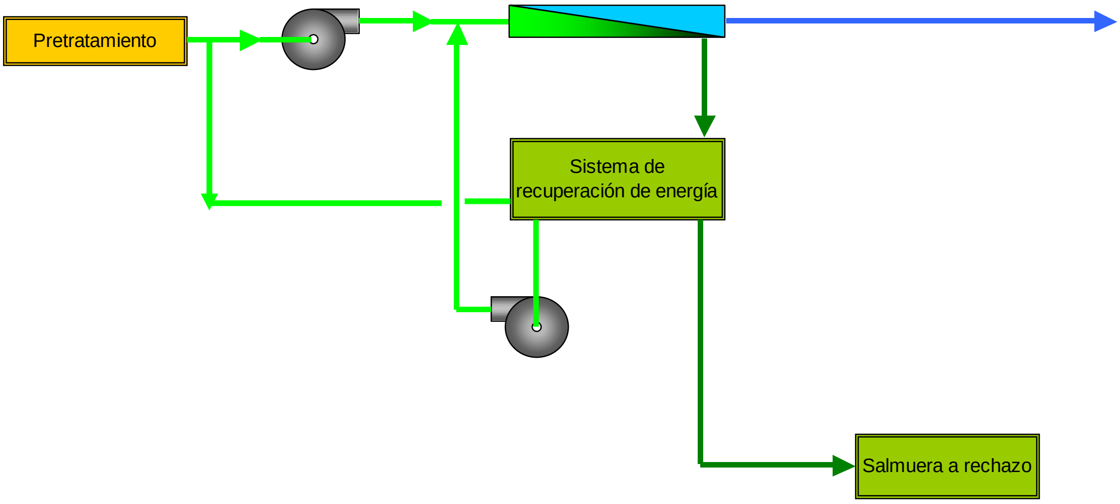
Figure 4.19 - Brine energy recovery system with PES



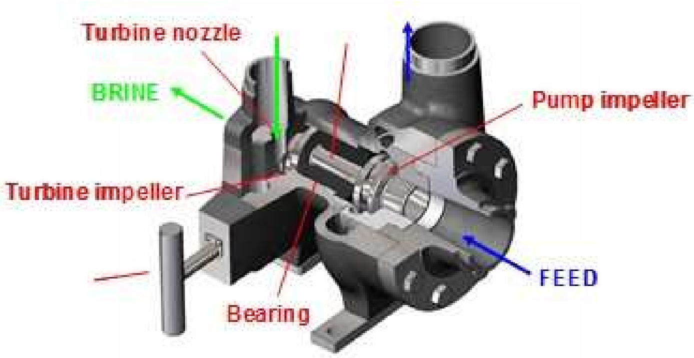

As can be seen in the previous Figure, part of the seawater is pumped to the membranes by a high-pressure pump, while the other part is sent to the PES, where it is placed in contact with the brine exiting the membranes, which is what transfers the energy.

The seawater at the PES outlet is at high pressure, but not enough for it to enter the membranes directly; thus, its pressure is increased by a recirculation pump and it is later introduced into the high-pressure pump discharge area, so the contents can enter the membranes together. This produces the Reverse Osmosis phenomenon. The brine must leave the PES with an estimate minimum pressure of 1 bar.

### 4.7.3. Turbocharger

The Turbocharger is a pump and a Pelton turbine that are tightly joined and specially designed for this. Its rotation speed is generally very high, in the order of 8,000 rpm., in order to achieve a high performance and keep the equipment small.

Figure 4.20 - Turbocharger (FEDCO courtesy)




## 4.8. Permeate Water Post-treatment

The permeate water at the membrane outlets is very unbalanced; it contains sodium chloride almost exclusively, which makes its pH acidic, Langelier Index negative and contributes with some strongly corrosive characteristics.

Although the permeate water from the membranes may be suitable for direct use in some industrial processes, in general, is not proper for many other uses, such as human consumption and agriculture,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since it lacks hardness and is very aggressive. For this reason, a post-treatment process for the permeate water is usually done to add the missing mineral salts (calcium, magnesium and bicarbonate), thus balancing it and making it suitable for use. The reasons for post-treatment application in permeate water can be summarized in:

- ✓ Water adaptation to the country's Health Regulations
- ✓ To avoid corrosion in the distribution pipes
- ✓ To adapt the water for the service in which it shall be used

### 4.8.1. Post-treatment processes

There are many processes to treat permeate water; among the most common, one can find:

- ✓ Blending with water from other sources
- ✓ $CO_2$ and lime or calcium hydroxide dosing
- ✓ $CO_2$ dosing and treatment in calcite or dolomite beds
- ✓ Disinfection
- ✓ Fluoride dosing

In the following sections, the previous post-treatment processes are explained.

#### 4.8.1.1. Blending

In this process, the permeate water that leaves the membranes is mixed with water from other sources so that the resulting mixture improves the characteristics of both. If only the dissolved solids content is considered and the permeate water has a content of 250 mg/L, the water from the other source, or brackish, to be mixed with the permeate, has a dissolved solids concentration of 2,500 mg/L, it would not be suitable water for human consumption, according to many Regulations and Standards. If we mix 5 $m^3$ of permeate water with 1 $m^3$ of brackish water, we will have 6 $m^3$ of 625 mg/L mixture water, which is suitable for consumption. This salt balance must be done with all the salts that make up brackish and permeate water, to know what water composition will result from the mixing. Carbon balance must also be established to calculate the mixture’s pH, the Langelier index, alkalinity and hardness.

To be able to execute this type of post-treatment, it is necessary to know the composition of the brackish water to be used very well, as this could provide salts that, even after mixing, may exceed the Regulations. It is also possible that compounds not allowed by the regulations exist, and, in this case, they cannot be used for this purpose.

Water from other sources may also contribute with bacteria and viruses in such quantities that, even after mixing, exceed the regulatory limits established.

For all these reasons, it is necessary to know the composition of "brackish" water very well before mixing and establishing the mixing ratio, to avoid exceeding any established guiding parameters.

If the water to be mixed with the permeate is already used in the supply, the problem is reduced, because if the water meets the standard, it will still serve its purposes even better after mixing.

This post-treatment class is relatively common in brackish water desalination plants. It mixes permeate water with a small amount of raw water to obtain a post-treatment water that complies with the existing regulation. This is not possible for seawater desalination plants, although product water from RO plants goes to a water supply service that receives water from other sources. If mixing can be performed, there must be adequate knowledge of the water quality from other sources.


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If it is intended to use mixing as a post-treatment, the appropriate mechanisms must also be provided to perform adequate homogenization, thus, guaranteeing a mixture with uniform quality.

#### 4.8.1.2. $CO_2$ and lime or calcium hydroxide dosage

The lime or calcium hydroxide dosage shall be the same as the quicklime or lime oxide measurements, which must previously be dissolved, resulting in the hydrolyzing reaction that produces calcium hydroxide.

$$CaO + H_2O \rightarrow Ca(OH)_2 + calor$$

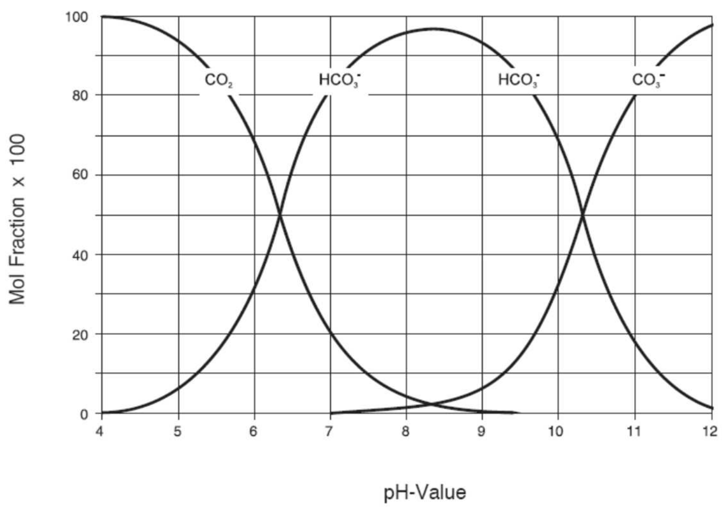
The advantage of using calcium hydroxide in comparison with lime is that the former prevents its dissolution with the consequent release of heat.

The reaction of calcium hydroxide with carbon dioxide is as follows:

$$2CO_2 + Ca(OH)_2 \rightarrow (CO_3H)_2Ca$$

With this dosage, lime content and hardness, bicarbonate content and alkalinity of the resulting water are increased. The amount of reagents to be administered will depend on the objective and quality to be achieved, if it is a matter of minimum hardness, a certain alkalinity value, a final pH within a range and/or a concrete Langelier Index. If $CO_2$ and $Ca(OH)_2$ are dosed in stoichiometric quantities, according to the previous reaction, the result is usually an encrusting water with very high pH. To decrease the Langelier index and pH, a little more $CO_2$ must be added. Chemical balance and species calculations must be performed to determine $CO_2$ doses, according to the curve shown in Figure 5.21, below.

Figure 4.21 – Carbonic Balance Curves (Dow Chemical courtesy)




#### 4.8.1.3. $CO_2$ dosage and treatment with calcite or dolomite beds

The difference between calcite and dolomite is in the content of calcium carbonate salts in each. In dolomite, the calcium carbonate content is between 50% and 60%, and the rest is magnesium carbonate. In calcite, the calcium carbonate content is over 99%, that is, all carbonates are in calcium carbonate form. Both forms have a carbonate content of more than 99%.

The calcite reaction is as follows:

$$CO_2 + CaCO_3 + H_2O \rightarrow Ca(CO_3H)_2$$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The dolomite reaction is as follows:

$$2CO_2 + CaCO_3 + MgCO_3 + 2H_2O \rightarrow Ca(CO_3H)_2 + Mg(CO_3H)_2$$

In both cases, a $CO_2$ molecule is needed for each bicarbonate molecule (calcium or magnesium) formed. However, considering the reaction with calcium hydroxide in the previous section, it can be found that two $CO_2$ molecules are needed for each calcium bicarbonate molecule formed. It demonstrates that more carbon dioxide is needed to achieve the same results if calcium hydroxide is used, rather than dolomites or calcites.

As it is with lime, the use of calcite or dolomite with $CO_2$ causes an increase in calcium and magnesium content (for dolomites), therefore, increasing water hardness, bicarbonate content and alkalinity after dosing.

The amount of reagents to be dosed will depend on the quality objective to be achieved.

With treatment in calcite or dolomite beds, the Langelier index that can be achieved is negative, but very close to zero. To achieve total balance (Langelier Index equal to zero), an infinite contact time would be necessary. If, according to the Regulation, the Langelier Index is zero or positive, it is necessary to add an amount of sodium hydroxide to the water after treatment, after the $CO_2$ dosage and passage through the beds.

#### 4.8.1.4. Disinfection

The water leaving the membranes, that is, the permeate water, does not contain bacteria or viruses, since the membranes are a complete barrier for bacteria and almost that for viruses. However, it can be contaminated through contact with the atmosphere, equipment and pipes located after the RO system. For this reason, to protect water from contamination after passing through the RO system in the desalination plant and distribution network, health regulations establish a disinfectant dosage for the water, before it is sent to the supply.

The usual disinfectants are chlorine, ozone, chloramines, etc.

The following can be added to chlorine disinfection: sodium hypochlorite, calcium hypochlorite, chlorine gas and/or chlorine dioxide.

In general, the most common products used to disinfect a water supply in the present location will be used.

#### 4.8.1.5. Fluoride Dosage

Sometimes drinking water regulations establish a minimum fluoride content. If this is the case in the country or area where the desalination plant is installed, the dosage of a chemical reagent containing fluoride, such as calcium fluoride, a water product for human consumption, shall be included.

## 4.9. Product Water Storage and Pumping

At a desalination plant facility, a product water storage tank must be provided, in addition to equipment to pump it into the supply system. The storage capacity does not have to be very large; a retention time of 5 minutes it may be sufficient, although it depends on the needs of each project.


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The product water pumps are generally horizontal centrifugal pumps with flow regulation by frequency variator or a control valve on the drive. If they are designed with the same capacity as an RO production line, and there are as many pumps as RO lines, they do not require flow regulation.

## 4.10. Brine Discharge

In seawater desalination plants, the brine produced in the desalination process is returned to the sea.

The impact produced by the brine resulting from RO technology on seawater is an increase in salinity in a given area. There is no increase in temperature with the discharge.

An adequate brine discharge system must be designed in order to minimize the environmental impact of brine in the sea and avoid its recirculation for the consumption of desalination water.

There must be good knowledge of the area where the discharge is shall be done. The coast dynamics, waves, tides, currents, winds and the bathymetry of the area must be well known. In the same way, and in order to monitor possible effects on the environment, it is necessary to raise the baseline, that is, to identify the existing marine species, abundance, tendency, benthic species, etc. All of this information will be used to design the discharge process and compare, as soon as the plant is commissioned, the initial situation before and after the discharge.

In addition, a study of the brine dispersion level in the sea must be carried out, in different hypotheses, to determine the area affected by increased salinity.

### 4.10.1. Brine Dispersion Studies

Brine dispersion can be defined as a mixing process that occurs in two different regions: the "near field" determined by the difference in density and the diffusion, and the "far field", determined by environmental conditions, such as ocean currents, waves, wind and temperature. To categorize these phenomena, calculation programs that include environmental, discharge flow, brine salinity, temperature and current data, among others, shall be used. In this manner, brine level and its expected concentration at each spot can be predicted.

These programs differ from each other, but the most suitable are those that consider the following factors, at least:

- ✓ Density difference between the brine and receiving environment
- ✓ Effect of temperature
- ✓ Saline diffusion
- ✓ Saline dispersion
- ✓ Tides
- ✓ Wind
- ✓ Bathymetry
- ✓ Coastal shape
- ✓ Effect of the osmotic pressure difference between the brine and the marine environment

The parameters that may vary in the Model and determine the discharge project are:

- ✓ Discharge site position
- ✓ Diffuser outlets: number, height, distance from one to another, speed and angle of exit.

### 4.10.2. Brine Discharge Classification


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Brine discharge can be classified in accordance with the discharge site:

- ✓ Direct surface discharge
- ✓ Direct submerged discharge in the coastline
- ✓ Discharge through a submerged multiport diffuser outfall

If protected species are detected in the area affected by salt water discharge that are sensitive seawater salinity increase, a seawater dilution process is also possible, although it is not a common requirement.

Direct surface discharge is the oldest type and was used in old distillation desalination plants.

Direct submerged discharge on the coast is a variant of the previous one, which allows the use of diffusers to accelerate the mixing process with seawater. It also avoids the visual impact of a superficial discharge.

Submerged discharge by submarine outfall is currently the most common type of brine discharge. It is ideal especially for large plants, since the brine flow rate is also high and it is necessary to ensure that the mixture occurs as soon as possible, avoid adverse effect. It also allows the discharge to be directed to the point where a lesser impact will be produced, also making it easier to avoid brine recirculation to the basin, which is another objective to be taken into account in the design.

## 4.11. Complementary services

The typical complementary services of an RO desalination plant are described below.

### 4.11.1. RO Membrane Chemical Cleaning Equipment

The RO membrane chemical cleaning equipment is generally composed of the following elements:

- ✓ A deposit to prepare chemical cleaning solution.
- ✓ Resistance when heating chemical cleaning solutions.
- ✓ Agitator
- ✓ Pumps to circulate the cleaning solution through the reverse osmosis racks.
- ✓ Cartridge filters
- ✓ Cleaning circuit

A chemical cleaning of the RO membranes is performed when:

- ✓ They suffer incrustation (detected by an increase in charge loss or a decrease in the production flow)
- ✓ After a long period of plant shutdown or as part of the scheduled maintenance program.

The membranes are exposed to two types of dirt that usually occur simultaneously. One is the incrustation that is produced by deposits on the membranes’ surface, which causes a loss in active surface and, consequently, the need for greater feed pressure to maintain the conversion, or the same product flow. Another type of incrustation is due to deposits in the membrane separator. This produces an increase in pressure loss for the passage of sea water, along the pressure pipe. As a consequence, the need to increase the supply pressure arises, in order to maintain product flow and prevent performance loss. Both can be associated with an increase in the passage of salts, although, if the case is very important, it is usually due to a degradation of the active membrane surface, and the only solution will be to exchange it.



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Therefore, both types of fouling cause an identical decrease in the water flow produced and a loss in permeate water quality.

When the differential pressure between the feed outlet and the rejection from a rack increases between 10% and 15%, the water flow decreases anywhere between 10% to 15%, and/or salt rejection decreases between 10 to 15%. In such cases, it is advisable perform a chemical cleaning of the membrane structure.

The chemical to be used to perform the chemical cleaning will depend on the type of contamination and its cause: salt deposition, metal oxides, bacterial growth or others.

Possible types of membrane contamination detected by changes in differential pressure (seawater inlet pressure minus brine outlet pressure), feed pressure and salt passage are described in the Table below.

Table 4.5 – Types of Contamination and Effects on RO Membrane Performance

| TYPE OF CONTAMINATION | POSSIBLE LOCATION | SIGNS IN DIFFERENTIAL PRESSURE | SIGNS IN THE PRESSURE FEED | SIGNS IN SALT PASSAGE |
|---|---|---|---|---|
| Metal oxides (ex: Fe, Mn, Cu, Ni, Zn) | First elements | Rapid increase | Rapid increase | Rapid increase |
| Colloidal fouling (organic or inorganic) | First elements | Gradual increase | Gradual increase | Slight increase |
| Mineral incrustations (ex: Ca, Mg, Ba, Sr) | Last elements | Moderate increase | Rapid increase | Marked increase |
| Polymerized Silica | Last elements | Normal to increased | Increased | Normal to increased |
| Biological fouling | Normally in first elements | Marked increase | Marked increase | Normal to increased |
| Organic fouling | All elements | Gradual increase | Increased | Decreased |
| Oxidant damage (ex: Cl2, ozone, KMnO4) | All elements | Normal to decreased | Decreased | Increased |
| Hydrolysis damage (outside pH range) | All elements | Normal to decreased | Decreased | Increased |
| Abrasion damage (carbon fines, etc.) | All elements | Normal to decreased | Decreased | Increased |
| Interconnector leaks | Random | Normal to decreased | Normal to decreased | Increased |

### 4.11.2. Displacement Equipment

O equipment de displacement das RO membranes is generally composed of the following elements:

- ✓ Permeate water deposit
- ✓ Pumps to circulate displaced water through the reverse osmosis racks and high-pressure equipment
- ✓ Displacement circuit

Displacement shall be performed whenever there is a prolonged stop in any of the Reverse Osmosis lines. With this equipment, seawater and brine displacement with permeate water shall be carried out on: high pressure pumps, recirculation pumps, pressure exchange systems, pipes, pressure pipes and membranes.

If the rinse is not performed, the pumping equipment and pipes can suffer corrosion and the membranes can undergo precipitations that can cause significant damage.



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The permeate water destined for this process shall be taken from a service water tank that contains permeate water, which must be periodically renewed.

### 4.11.3. Multimedia Filter Washing Equipment

Multimedia filter backwashing is usually done with water and air. The backwash water can be of three types: raw sea water, filtered sea water or brine.

Depending on the option chosen, one project or another is carried out. It must be considered that if the filters are washed with brine, a seawater displacement stage from the filter brine and pipes is necessary after the wash.

The filter backwashing equipment normally consists of the following items:

- ✓ Centrifugal backwashing pumps: the flow rate of these pumps will depend on the flushing speed needed, head loss and the circuit's geometric height.
- ✓ Blowers
- ✓ Set of automatic valves in the filters for automatic washing.
- ✓ Circuits for water wash, air wash and displacement.

### 4.11.4. Vacuum Equipment for Pump Priming

When the collection pumps are mounted with vacuum suction, it is necessary to install priming equipment, which ensures that air that could cause cavitation does not enter. There is also the possibility to acquire self-priming pumps, each with a small vacuum equipment.

### 4.11.5. Chemical Cleaning Effluent Neutralization Equipment

The water used to wash RO or UF membranes, as well as other chemical effluents, can be basic, acidic or contain residual chlorine; therefore, it will need to be neutralized (for example, with sulfuric acid, sodium hydroxide or sodium bisulfite) before it is mixed with brine to be transported to the brine collector.

The chemical cleaning equipment for effluent neutralization consists of the following:

- ✓ Neutralization tank
- ✓ Dosage of neutralizing reagents
- ✓ Agitation system
- ✓ Neutralized water transport to brine discharge

### 4.11.6. Filter Backwash Water Treatment Equipment

The filter washing water can be mixed with brine to be discharged into the sea, provided that environmental regulations and licenses are respected or the water is treated in a filter washing water treatment system. This system normally consists of the following equipment:

- ✓ Settling tank
- ✓ Sludge extraction pumps
- ✓ Sludge dryer
- ✓ Sludge evacuation container
- ✓ System to transport sedimented water to the brine discharge

### 4.11.7. Instruments and Services Air Equipment


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Desalination plants usually install air compression equipment for instruments and services. This equipment is typically composed of:

- ✓ Air suction muffler filters.
- ✓ Vacuum regulating valves.
- ✓ Compressors (ex.: rotary screw).
- ✓ Oil filters
- ✓ Air/oil separators
- ✓ Minimum pressure valves
- ✓ Fans to cool air
- ✓ Air/water separators with electronic purge valve
- ✓ Refrigerated compressor dryers
- ✓ Coalescing pre-filters with electronic purge valve
- ✓ Post filters with electronic purge valve
- ✓ Compressed air tank with electronic purge valve
- ✓ Silent cabin
- ✓ Control and monitoring system
- ✓ Accessories required for the connection of these elements
- ✓ Compressed air circuit consisting of a network of tubes and accessories usually made of copper or galvanized steel, with connection points distributed throughout the plant.

### 4.11.8. Service Water Equipment

In desalination plants, a service water equipment is usually installed. This equipment is typically composed of a pressure group and a service water circuit.

The pressure group typically consists of a pressurized accumulator tank and multicellular pumps in AISI 316L steel.

The service water circuit consists of a network of pipes and connections distributed throughout the plant, usually PP or HDPE.

### 4.11.9. Cranes and Lifting Elements

For equipment maintenance tasks, there are cranes and winches that can be electric or manual. Usually, at least one overhead crane is installed in the Process Room, for maintenance of high-pressure and recirculation pumps, another in the Intake Room for intake pumps maintenance and a last for the maintenance of product water pumps, with sufficient power to lift the heaviest part of the group, which is the engine.

### 4.11.10. Security Systems

In the chemical reagent area, eye wash stations must be installed in accordance with current regulations.

According to the safety and health study, the necessary equipment must be available for the safe plant operation.

### 4.11.11. Fire Fighting System

Fire systems in desalination plants typically consist of central monitoring and detection system control. This panel contains different manual buttons, alarm bells and detectors connected to it. The latter are of the appropriate type, according to placement and the quality to be monitored (smoke,



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gases, flames or heat), to guarantee maximum speed in the detection of a possible fire. The plant controls the various areas or sectors in which it was divided, including seawater intake. It is also linked to the plant's distributed control system.

For the rest of the installation, the fire system is usually composed of fixed fire extinguishers, strategically located on the premises and complemented with portable fire extinguishers in sufficient quantity and quality to attack the fires that could take place, following applicable regulation.

### 4.11.12. Ventilation, heating and air-conditioning systems

A desalination plant must be equipped with ventilation, heating and air conditioning systems necessary to ensure safety, compliance with applicable regulations and its proper operation.

### 4.11.13. Workshops, warehouses, offices, laboratories

Desalination plants usually have a workshop for mechanical issues and another for electricity and instrumentation, equipped with compressed air and the tools and instruments necessary for adequate preventive maintenance of the installation; warehouses for spare parts and storage of chemicals; an administrative building with a desalination plant control room, offices, changing rooms, bathrooms, a casino, meeting rooms and a laboratory with equipment and instruments necessary for the correct quality control of seawater, permeate and product water.

## 4.12. Instrumentation and Control

### 4.12.1. Instrumentation

In desalination plants, the installation of field measurement instruments is necessary to enable the startup, operation, shutdown, control, equipment supervision and inherent processes. It is also necessary to install instruments that inform equipment status, to perform their maintenance and ensure their compliance with environmental regulations. Most measurements made by these instruments are monitored and recorded in the desalination plant’s control system. Thus, many of the field measuring instruments, aside from local data, provide the corresponding signal to the control system.

The instruments typically installed in a desalination plant are the following:

- ✓ Flow measurement instrumentation
- ✓ Pressure measurement instrumentation
- ✓ Level measurement instrumentation
- ✓ Temperature measurement instrumentation
- ✓ Level floats, contact switches and pressure switches.
- ✓ Analytical instrumentation
    - For turbidity measurements
    - For conductivity measurements
    - For pH measurements
    - For Redox potential, ORP measurements
    - For chlorine measurements
    - Others: hydrocarbon meters, hardness meters, silica content meters, etc.

### 4.12.2. Control System

The desalination plant’s operation, supervision and control are carried out remotely from its control room, through the control system.


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The control system includes all software, licenses, DCS (distributed control system) and HMI (human machine interface) equipment, system inputs and outputs and all necessary devices, accessories and auxiliary equipment, as well as programming for the correct operation and maintenance of the desalination plant.

The objectives of a control system in a desalination plant are:

- ✓ To ensure the correct automatic operation of the plant, through a centralized process control in real time.
- ✓ To ensure that information is obtained from all processes.
- ✓ To ensure proper equipment maintenance.
- ✓ To ensure compliance with environmental requirements.
- ✓ To control all processes from a single point and in real time.
- ✓ To enable a high desalination plant availability.

There are basically two control systems options with centralized supervision currently in use:

- ✓ Distributed Control System.
- ✓ PLCs + SCADA

Distributed Control Systems (DCS) are typically installed in large-capacity desalination plants, which handle a large number of signals.

The Distributed Control System (DCS) includes the following functions: data acquisition, PID control, discrete control, open and closed loop control systems, human-machine interface (system and subsystem graphics), manual and automatic operation, alarms, interlocks , drives, event logging and sequential events, trend curves, management reports, system diagnostics and their visualization and different security levels for password access to the various system functions.

A Distributed Control System is composed of:

- ✓ Operation and engineering stations (Operation, Supervision and Control): includes hardware, software and necessary licenses for computers, servers, PCs and printers.
- ✓ Management data communication network: this network provides the exchange of information between the operating and engineering stations and the servers between them and the process controllers.
- ✓ Process controllers.
- ✓ Process data communication network: this network provides communication between controllers and I/O cabinets.
- ✓ Cabinets to house the devices and cards needed for I/O communication, local and remote.
- ✓ Field network: this network connects the I/O cabinets with desalination plant instruments and equipment.
- ✓ Wiring, troughs, etc.

## 4.13. Electrical System

Electricity consumers at a desalination plant are very diverse, from lighting to air conditioning, cranes and control systems; large consumers, such as high-pressure pumps, and small consumers, such as metering pumps; continuous consumers, occasional consumers, etc. To make a correct draft of the Electrical System and estimate the desalination plant's electrical consumption, it is necessary to know all of them.


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The different voltage levels that must be available in the desalination plant for different consumers must be established.

For the Electrical System project, the following must be determined:

- ✓ Total installed power: the sum of all unit consumers installed by the nominal power.
- ✓ Power at full load: when more energy is being consumed at the desalination plant, consumers in simultaneous operation and the sum of the units in operation are considered for the power to be installed.

With this calculation, it is possible to know the power to be contracted, that shall be equal to the maximum load power. If it is in kW, it shall be divided by the power factor, and the power shall be provided in KVA.

There will be moments of greater energy consumption, such as at the starting operation of a high-power consumer; since it will be instantaneous, the electric company must be informed, but it will not be necessary to contract this amount of power continuously.

Once all these data have been established, the electric company must inform about the electrical connection required and its voltage. With this information, the Electrical Installation System can be designed.

The electrical system of a desalination plant usually consists of the following systems:

- ✓ Medium voltage power line.
- ✓ Electrical substation: sections, protection, entrance, exit and measurement cabinets, transformers, input, output and protection cells.
- ✓ Transformation center for the different voltage levels demanded by the plant's consumers, consisting of transformers, input, output, measurement and cell protection.
- ✓ Medium voltage electric cabinets to supply medium voltage consumers.
- ✓ Distribution cabinets for low voltage consumers, including outputs for MCCs, batteries, general switchboards, etc.
- ✓ Motor Control Centers.
- ✓ Grounding network.
- ✓ Capacitor batteries for power factor correction.
- ✓ Equipment frequency inverters.

# 5. Description of the Fortaleza Desalination Plant

The solutions presented below are a reference study for the implementation of the Fortaleza Desalination Plant, developed by the Authorized Company in PMI scope and adapted by CAGECE, serving as basis for the posterior development of the Basic and Executive Projects.

The adoption of a pretreatment system with double-stage filtration was proposed considering the available analytical data extracted from the “Information for EDAM Fortaleza\Water Monitoring.pdf document. The Marine Sciences Institute of the Federal University of Ceará was also consulted, coordinating the monitoring and dredging studies performed at Porto do Mucuripe.

They confirmed that the solids found are sands carried by the sea currents in the area, and that the chosen site is at a safe distance from wastewater outfalls discharges and where the risk of algal blooms is low.



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All this information led to the design of a conventional, robust pre-treatment, with low implantation and operational cost, which is ideal for capturing any sand not sedimented in the disassembly process.

Another important point is the ease of operation with low consumption of chemical products, much lower than other systems would require, such as ultrafiltration, that is more sensitive to sand abrasion.

The process details and design criteria are presented in Attachment 14.3- Process Calculation Memory.

## 5.1. Initial Data

To determine the initial data that authorize the elaboration of the desalination plant, previous information about Fortaleza was considered, which is listed in in the bibliographical references. Based on this information, the starting data is described in the sections below.

### 5.1.1. Plant Capacity

The desalination plant production capacity shall be 1m$^3$/s with four lines. The unit capacity per line is 0.25 m$^3$/s.

For the proposed desalination plant design, a 0.3% increase in produced flow for internal consumption was considered.

The nominal production capacity, therefore, is:

- ✓ Project production: 86,400 m$^3$/day
- ✓ Number of lines: 4
- ✓ Production by line: 21,600 m$^3$/day

Production capacity, including the safety amount, is:

- ✓ Project production: 86,659 m$^3$/day
- ✓ Number of lines: 4
- ✓ Production by line: 21,664.8 m$^3$/day

Seawater flow to be collected:

- ✓ Nominal water flow to be collected: 192,576 m$^3$/day
- ✓ Maximum flow during filter displacement: 207,388.8 m$^3$/day

Plant Conversions:

- ✓ RO Conversion: 45%
- ✓ Global Conversion: 44.86%
- ✓ Global conversion during displacement: 41.66%

### 5.1.2. Plant Availability

The plant's desalination equipment requires maintenance for proper operation so that desalinated water production cannot be maintained for 24 hours a day, 365 days a year. Based on previous experience in the operation and maintenance of similar desalination plants, an availability of 95.89% per year is adequate for proper plant operation. This 95.89% value per year was considered for the project. To increase this availability, a redundant RO line must be included, but such an investment not compensate this increase in availability, as cost would be considerably increased and this RO line would be inoperative most of the time, which is not recommended.



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### 5.1.3. Environmental Conditions

The environmental conditions of the city of Fortaleza are detailed below:

- ✓ Maximum annual temperature: 30.8°C
- ✓ Minimum annual temperature: 23.9°C
- ✓ Humidity: 77.5%
- ✓ Average annual rainfall: 1,668.6 mm

The region selected for the implementation of the desalination plant, Praia do Futuro, is considered the second highest for sea spray corrosion in the world, according to studies by the Eletrobrás Research Center (Cepel), fact reinforced by studies developed by INOVACON,COOPERCON-CE, SINDUSCON-CE, CIMENTO APODI e PEC/UFC (http://www.pec.ufc.br/images/Edital/16-11-Cartilha-Agressividade-do-Ar-Small-Spreads.pdf). This has also been reported by the local power company, which stated that this region has a sea spray rate of 1,832mg/m³/day, forcing it to use special technologies such as aluminum alloy hardware and other materials more resistant to salt pollution. Due to this peculiarity, extra attention should be paid to the adoption of materials and equipment, in order to obtain the lowest cost-benefit for the desalination plant.

### 5.1.4. Characteristics of the Water to be Treated

Raw water will come from the coast of Fortaleza.

The considered tidal race is of 4.4 meters, the low tide -1.60 m, and high tide 2.80 m, with the average sea level as reference.

The Attachment 14.6 presents a set of analyzes carried out in the area foreseen for water intake and concentrate disposal.

The analysis shown below was made for the projected seawater, chemically balanced so that the anion concentration expressed in meq/L is equal to that of cations.

Table 5.6 shows the physicochemical parameters of seawater in the design proposed.

For the plant design, the maximum and minimum temperatures from the aforementioned information were considered.

- ✓ Maximum Temperature: 30 °C
- ✓ Minimum Temperature: 20 °C
- ✓ Average Temperature: 27 °C



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Table 5.6 – Projected Seawater Physicochemical Parameters

**Planta de Fortaleza**

| | FOLHA DE ANÁLISE | |
|---|---|---|

| | | | |
|---|---|---|---|
| CLIENTE | | CONTRATO | |
| LABORATÓRIO | | REFERÊNCIA | |
| TIPO DE ÁGUA | DO MAR | DATA | November-17 |
| LUGAR DE AMOSTRAGEM | Costa de Fortaleza | | |

| ANÁLISE FISICO-QUIMICO | | | | | |
|---|---|---|---|---|---|
| TURBIDEZ | 1 | U.N.F. | PH | 7,90 | |
| COR | 1 | Pt-Co | CONDUTIBILIDADE | 58.846,93 | µmhos/cm. |
| ODOR | 0 | TON | T.D.S. | 39.051,86 | mg/L |
| ASPECTO | | | ALCALINIDADE | 133,85 | ppm CO3Ca |
| TEMPERATURA | 27 | ºC | DUREZAE | 6.403,60 | ppm CO3Ca |
| **COMPOSIÇÃO IONICA** | | | | | |
| **ELEMENTO** | **mg/L** | **meq/L** | **ELEMENTO** | **mg/L** | **meq/L** |
| Ca++ | 504,55 | 25,18 | SO4= | 4.159,73 | 86,61 |
| Mg++ | 1.249,42 | 102,78 | Cl- | 20.425,10 | 576,12 |
| Na+ | 12.110,61 | 526,75 | CO3H- | 142,78 | 2,34 |
| K+ | 420,00 | 10,74 | F- | 0,30 | 0,02 |
| Ba++ | 0,02 | 0,00 | Br- | 0,00 | 0,00 |
| Sr++ | 5,10 | 0,12 | I- | 0,00 | 0,00 |
| Fe++ | 0,00 | 0,00 | NO2- | 0,00 | 0,00 |
| NH4+ | 0,30 | 0,02 | NO3- | 10,70 | 0,17 |
| Ag+ | 0,00 | 0,00 | CO3= | 10,04 | 0,33 |
| Mn++ | 0,00 | 0,00 | PO4≡ | 0,00 | 0,00 |
| Zn++ | 0,00 | 0,00 | S= | 0,00 | 0,00 |
| Cu++ | 0,00 | 0,00 | SiO2 (coloidal) | 0,20 | 0,00 |
| Al+++ | 0,00 | 0,00 | SiO2 (soluble) | 8,20 | 0,14 |
| Fe+++ | 0,00 | 0,00 | CO2 | 1,23 | 0,03 |
| H+ | | 0,00 | OH- | | 0,00 |
| **TOTAL** | **14.290,00** | **665,59** | **TOTAL** | **24.756,85** | **665,59** |

| OUTRAS DETERMINAÇÕES | | | |
|---|---|---|---|
| **SUBSTÂNCIAS TOXICAS** | **mg/L** | **Matéria orgânica e outros** | **mg/L** |
| Arsênio | 0,00 | DBO5 | 2,00 |
| Cádmo | 0,00 | DQO | 5,00 |
| Bário | 5,00 | Nitrogêno proteico | 0,00 |
| Mercurio | 0,00 | Compostos fenólicose | 0,00 |
| Chumbo | 0,00 | Detergentes | 0,00 |
| Selênio | 0,00 | Oleos e graxas | 0,00 |
| Cromo total | 0,00 | Hidrocarbonetos | 0,00 |
| Cromo | 0,00 | Sólidos em suspensão | 10,00 |

### 5.1.5. Product Water Characteristics

The system's net production capacity shall be of 1 m$^3$/s, with an annual availability rate of 95.89%. The desalinated water produced shall be delivered by the DISTRIBUTION COMPANY at the EXISTING SYSTEM DELIVERY POINTS, meeting potability standards specified in Attachments XX and XXI of Consolidation Ordinance nr. 5, of September 28th, 2017 (which revoked Ordinance 2914/2011), or by a specific standard that may replace or update it, and, as an alternative, as



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recommended by the World Health Organization (2011). The limiting factor in this legislation is the chloride concentration content of 250 mg/L.[2]

### 5.1.6. Battery Limits

The battery limits (included) proposed for this Project are the following:

- ✓ Seawater: seawater intake tower.
- ✓ Product water: water supply pipelines to the DELIVERY POINTS
- ✓ Power supply: desalination plant electrical substation for the installation of the medium voltage source and power transmission line to be implemented from the local energy concessionaire substation;
- ✓ Brine: brine discharge outfall.

## 5.2. Process Justification

According to the arguments presented in previous sections about the processes that make up a seawater desalination plant, this section will justify the process line chosen for the Fortaleza Desalination Plant, based on good engineering practice, current state of the art, local conditions and the intended use of desalinated water to minimize CAPEX and OPEX, providing a sustainable environmental solution. The elaboration of the basic and executive projects may present different solutions from the one adopted in this study, but the premises presented in the Term of Reference must be met.

The technology chosen for desalination is reverse osmosis by spiral wound 8-inch aromatic polyamide membranes. This membrane type has been selected because it is currently the most widely used in the world for RO desalination plants, ensuring an ideal process solution in terms of energy consumption and price competitiveness.

Proper choice and design of seawater intake and pretreatment are critical to ensure the project and proper operation of RO seawater desalination plants. It is necessary to collect the best quality water possible (without suspended matter, organic substances, heavy metals and poorly soluble elements) and condition it properly to avoid clogging and ensure the integrity of the RO membranes. For this purpose, suspended organic and inorganic matter should be eliminated and their salts should not become incrusted, but concentrated in seawater through reverse osmosis. Intake and chemical and physical pretreatments are designed for this purpose.

The algae content of Fortaleza coast seawater is not high, but may contain fine sands found throughout the water column, due to the turbulence suffered by the strong currents off the coast. There are also hydrocarbons, oils and fats from ships; therefore, it is advisable to collect seawater from a deep site, to avoid the collection of such material that concentrates on the surface.

In either case, given the high currents that occur, a dose of activated charcoal powder has been planned, which shall be used in an emergency if considerable concentrations of hydrocarbons, oils or fats are found.

The pre-treatment selected for this project is directly related to the quality of water available, which in turn is directly related to the type and location of the intake adopted.

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2 World Health Organization (WHO). Safe Drinking-water from Desalination, 2011. Disponível em <https://www.who.int/water_sanitation_health/publications/desalination_guidance/en/>



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Process details shall be provided at the moment of elaboration of the basic and executive projects.

The main desalination process pretreatment systems are: filtration through membranes and filter beds.

Membrane filtration technologies in the ultrafiltration and microfiltration range show advantages in the maintenance of effluent quality in comparison with conventional granular bed filters.

Mono and multilayer filters are, in turn, a successfully used technology in desalination plants worldwide.

The selection a pre-treatment method will depend fundamentally on the characteristics of the project itself, concerning the possibility of obtaining good quality seawater with low variability. The final decision was made with basis on operating and investment costs, which would result in a competitive desalinated water price.

Among the conditions to be considered when selecting a pre-treatment type, we can emphasize:

(i) Size distribution of particles suspended in seawater. When there is a large variation in the size of suspended solids in seawater, micro or ultrafiltration membranes, eliminate them more efficiently due to the uniform membrane pore size. In a sand filter, there is a large variability in stage sizes due to filter bed irregularities; therefore, they are more likely to have worse filtered water quality episodes when a change in seawater composition takes place.

When the water available shows slight composition variability, a simple adjustment in the coagulant dose at the filter inlet will be sufficient to restore filtered water quality.

The location and depth of the designed intake tower, as well as available data indicate little variability in the raw water that will feed the desalination plant.

ii) Colloidal material, silt and pathogens: these compounds are best retained by ultra or microfiltration membranes. Prior hypochlorite disinfection and/or use of coagulants at the filter inlet may be sufficient to grant the quality required for the water to enter the reverse osmosis system. High concentrations of these compounds are not expected in the area selected for the present project.

iii) Sudden changes in water quality due to an accident or discharge, causing pH variations, oil and grease contamination and high temperatures can irreversibly damage the ultra and microfiltration membranes; in these circumstances, sand filters are much more robust.

iv) The presence of sharp particles can break the membrane fibers. Therefore, a 120-micron railing/screen (microscreening) system is required prior to entry into the ultra and microfiltration membranes.

v) The water filtered through multimedia filters requires a final refinement through cartridge filters with a 5-micron stage size. If ultrafiltration membranes are used, these filters are not required.

vi) In algal bloom episodes, gravity sand filters seem to be more advisable. The pressure required to operate ultrafiltration membranes would break the algae, emptying its organic content into the raw water and thus accelerating the growth of a biofilm on the osmosis membranes.

vii) When the algae content is too high, to avoid hindrances in the plant's operation, it is recommended to provide a dissolved air flotation system (DAF) that eliminates most algae. This system is usually installed through bypass and is used only when such episodes occur. The available information does not indicate any risk of algae bloom in the area selected for the intake tower.



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viii) Available area: membrane technology requires less deployment space, in average 30% to 50% less than filters. In view of implementation costs, it should also be noted that the filters do not need to be covered and can be installed outdoors; in contrast, ultrafiltration systems need to be deployed inside a building.

With the information available on seawater quality in the selected intake area, no large variation in water composition, outbreaks of organic contamination, or possible algal blooms that could endanger plant operation are to be expected.

The possibility of contamination by oil spills is mitigated with the location and depth of the intake tower.

Seawater data available in the area of this project does not show the need to install rails for solids or debris removal. However, due to sea currents, seawater may contain varying amounts of sand, so a sand trap area is to be set up before the pumping zone entrance.

Considering the aforementioned, the proposed pretreatment system is a two-stage filtration through filter beds.

However, pretreatment definitive choice shall be made when the analytical sampling studies are elaborated in the next phases (basic and executive projects).

### 5.2.1. Intake Tower

For the intake of seawater, the proposal is a submerged intake tower, 2500 meters away from the coast and 14 meters deep, approximately. The water collected shall be conducted through communicating vessels to an onshore seawater chamber. A baffle system will be designed for it to increase permanence time and allow potential sand to be captured. The sand extracted will be deposited on the shore or at the approved site determined by the environmental impact study.

Water speed shall be low inside the intake tower, at its openings and within a five-meter radius from the intake pipe, to avoid producing strong currents that drag fish in, and so that, in case they swim into the intake tower, they can manage to swim out.

However, intake pipe diameter was projected so that speed is not excessively low because the captured sand would sediment inside. In any case, the intake pipe and tower design shall include a pipe scraping cleaning system (pigging). Thus, the intake tower must allow the adoption of this system.

The seawater pumping system design will contain vertical seawater pumps, that will pump the water collected in the process. This type of pump was chosen because the NPSH (Net Positive Suction Head) available in the seawater tank is very low, making the horizontal pump option in command much more expensive in CAPEX terms. Installation experience of this type of pump for seawater desalination plants indicates the adoption of PREN> 40 stainless steel pumps, including cathodic protection to prevent corrosion.

### 5.2.2. Pretreatment

The chemical pretreatment shall consist of:

- ✓ Sulfuric acid to adjust pH, facilitate disinfection and reduce dispersant consumption.
- ✓ Shock-dosed sodium hypochlorite for disinfection of elements and equipment. Continuous



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use of this reagent with the desalination plant in operation is not recommended, as experience has shown that there is greater fouling of the RO membranes when chlorine is used continuously.

- ✓ Shock-dosed sodium hypochlorite for disinfection of elements and equipment, dosing of this reagent is not recommended continuously, with desalination plant in operation, as experience has shown that there is greater fouling of OI membranes when chlorine dosing. in continuous.
- ✓ Ferric chloride coagulants to facilitate coagulation and subsequent retention in pretreatment filtration stages of suspended solids contained in seawater.
- ✓ Dispersants to prevent precipitation of calcium sulfate, strontium sulfate, calcium fluoride and other salts when seawater is concentrated in the membranes, will be applied. Its function is to prevent the formation of crystalline salt networks, keeping the ions in dispersion and allowing their solubility limit to be exceeded.
- ✓ Sodium metabisulfite will be used for chlorine neutralization after shock chlorination and as safety to reduce possible oxidants before the seawater enters the RO process, since aromatic polyamide membranes show a low tolerance to oxidizing substances. Metabisulfite reacts with chlorine and other oxidants contained in seawater, such as dissolved oxygen, preventing them from reaching and damaging the membranes. In addition, a sodium metabisulfite dose shall be applied to the brine deposit prior to discharge into the sea.

For the physical pretreatment, the following systems were designed:

- ✓ Activated carbon dosage to eliminate potential hydrocarbons, oils and fats.
- ✓ First stage filtration in sand and anthracite filter media.
- ✓ Second filtration step on multimedia sand filters.
- ✓ Cartridge filters with 5 nominal microns rating.

This pretreatment has been designed from a safety point of view, as there are two serial filtration stages, and thus, good elimination of suspended solids is ensured. The filtration cut-off size was chosen based on experience with other desalination plants with similar water quality.

The filtration speeds adopted are conservative, considering the operation references of different projects currently operated by GS INIMA:

- ✓ Carboneras (120,000 $m^3$/day) 12-14 m/h;
- ✓ Cap d'Jinet (100,000 $m^3$/day), 8.5-9.5 m/h with first-stage filters and between 13 and 15 m/h for second-stage filters;
- ✓ Djerba (50,000 $m^3$/day): 6.5-9.5 m/h with first-stage filters and between 9.5 and 10.5 m/h for second-stage filters;
- ✓ Mostaganem (200,000 $m^3$/day), 8.5-9.5 m/h with first-stage filters and between 13 and 15 m/h for second-stage filters.

Two filtration steps were elected instead of a single step to provide greater pretreatment process security. In addition to being selected instead of ultrafiltration, as it presents a more robust filtration that has two steps to eliminate suspended solids, it allows cutoff size selection in each step, adjusting to the characteristics of the matter contained in the water from Fortaleza’s coastline.

A dissolved air flotation system, DAF, was not included, since, as previously mentioned, seawater algae content is not high and there are no red tides in the Fortaleza coast.



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A filtration stage has been added to the cartridge filters after the two stages of closed pressure filters. The cartridge filters provide a final safety barrier against solids contained in seawater before entrance into the RO membranes.

### 5.2.3. Reverse Osmosis System Description

The planned Reverse Osmosis system shall be one step and one stage, and brine energy recovery shall be done by pressure exchange systems.

The number of selected RO lines is four (4). This amount of lines was selected because it allows flexibility in production; thus, it can produce: 0.25 $m^3/s$, 0.5 $m^3/s$, 0.75 $m^3/s$ or 1 $m^3/s$. In addition, the racks represent 21.150 $m^3$/day of production, which means they must be large; therefore, the pumps and motors per line shall also be large, which guarantees a higher yield and less energy consumption per $m^3$ of produced desalinated water.

The proposed Pressure Exchange Systems (PES) present a lower specific energy consumption when compared to Pelton turbines. The PES shall be complemented with recirculation pumps equipped with a frequency inverter.

The line pressure tubes will be connected by a multiport system that facilitates assembly and saves high-pressure tube work.

The conversion factor corresponding to the Reverse Osmosis type elected is of 45%, and once the desalination plant project has been advanced, this conversion factor shall be optimized to guarantee the lowest energy consumption possible.

The high-pressure pumping system shall be composed of a high-pressure pump, and in its suction, a booster pump equipped with a frequency variator to guarantee production control in different operating conditions: variations in seawater temperature and pressure loss in the RO membrane lines due to incrustation and age.

Permeate water from Reverse Osmosis has a very negative Langelier index, which is why it is very corrosive. The post-treatment was designed to obtain a Langelier index between 0 and 0.4 to prevent the water corrosiveness or fouling, thus preserving the integrity of the water's distribution pipes. In addition, fluorine and sodium hypochlorite shall be added to condition the water to the quality level required for drinking water in Brazil.

The post-treatment elected consists of:

- ✓ Carbon dioxide dosage.
- ✓ Sodium hydroxide dosage.
- ✓ Sodium fluorosilicate dosage.
- ✓ Sodium hypochlorite dosage.

The calcium hydroxide dosage was selected against other remineralizing treatments, such as calcite or dolomite. We have extensive experience with this post-treatment process and the investment needed is less than it would be that needed for the use of calcite or dolomite towers.

The use of $CO_2$, hypochlorite and fluorosilicate (for those countries whose regulation requires fluoride in water) is the same as elected in the vast majority of RO seawater desalination plants for the production of drinking water.



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A product water tank was included to store the water produced in the 1,800 $m^3$ desalination plant, which allows a residence time of 30 minutes.

### 5.2.4. Brine Disposal

A saline concentrate final disposal system through marine outfall was proposed, 1200 meters away the coast. Brine diffusers shall be installed in its final section, to ensure rapid mixing of brine and seawater, so that salinity addition in the discharge area is as small as possible. The number of diffusers, their angle and discharge speed will also be chosen to minimize the discharge impact area.

The seawater intake and brine discharge sites were chosen considering the direction of currents, to prevent recirculation of the brine discharge into the intake system.

### 5.2.5. Complementary Services

The complementary services projected for the desalination plant are:

- ✓ Closed filter backwashing system: the filters shall be backwashed with brine and air. The brine wash will be done by washing pumps that shall pump the brine from a brine tank. It has been found that the brine produces effective filter washing and also reduces absorption of seawater, thus increasing the plant’s recovery (water produced / water collected). The air shall be obtained by blowers.
- ✓ RO chemical cleaning system for RO membranes: this system will make it possible to clean the RO lines before pressure drop increases or permeate water loses quality.
- ✓ Displacement system: this system allows, before production stops, to move all seawater and brine in the equipment, tubes and valves from the Reverse Osmosis process. Seawater and brine at zero speed can cause corrosion in these elements. Brine can also produce salt precipitations, because over time the dispersant will no longer be effective.
- ✓ Drinking water and wastewater systems.
- ✓ Drainage, ventilation and drains system.
- ✓ Transport and lifting systems.
- ✓ Firefighting system.
- ✓ Ventilation and air conditioning system.
- ✓ Laboratory and mechanical workshop material, instrumentation and electrical equipment.
- ✓ Replacement parts.

## 5.3. Design Criteria

The criteria considered for the desalination plant project are included below:

- ✓ To perform a correct distribution of the different plant components, considering the logical process sequence, operational safety, attainment of an easy and efficient exploration and the site’s topographic and geotechnical characteristics.
- ✓ To provide facilities with sufficient flexibility to facilitate operating maneuvers, as well as maximum safety and reliability conditions.
- ✓ To provide quality to civil works, equipment and installations that allow a quality-price ratio that fits such works, while ensuring the achievement of quality and production requirements.
- ✓ To provide facilities with sufficient flexibility to facilitate operation and maintenance maneuvers, without jeopardizing production.
- ✓ Integrate the Desalination Plant to the selected site as a harmonious whole, in mechanical equipment and in the construction of buildings, other facilities and civil works.



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- ✓ Minimize the environmental impact of facilities to ensure their full integration into the environment, in the best conditions.
- ✓ Finally, to provide quality engineering work appropriate for the operating conditions and location.

## 5.4. Project Proposal Description

### 5.4.1. Electromechanical Devices

#### 5.4.1.1. Seawater Intake

The intake is performed through an intake tower located at a bathymetry of 14.0 m to collect seawater of appropriate quality for the Reverse Osmosis process, thus avoiding oils, fats and hydrocarbons. The collected seawater shall be conducted through a high-density polyethylene (HDPE) line to a suction chamber, a seawater receiving well, located on the coast. The seawater enters this chamber through communicating vessels. The tube diameter is 1600 mm (external diameter).

Sulfuric acid and sodium hypochlorite dosages were provided for the intake tower, for the cleaning of its own structure and the seawater marine outfall.

At the seawater receiving well inlet, the water shall be conducted through a labyrinth at very low speed, to increase permanence time in the chamber and produce decantation of the fine sands possibly captured, which will be returned to the coast.

#### 5.4.1.2. Seawater Pumping

The seawater pumping unit can supply the plant with up to 8,641 $m^3/h$ and is composed of 5 (4 + 1) centrifugal pumps, with a unit capacity of 2,293 $m^3/h$ and TDH of 82 m.

The five seawater pumps shall be installed in parallel, with one established as a reserve. The pumps shall transport the seawater from the receiving chamber to the mixing chambers. The discharge collector for the Plant shall have a diameter of 1200 mm, which shall provide a seawater speed of less than 2 m/s inside the pipe, and shall be built in GRP, PN-10 and 5,000 $N/m^2$.

The projected seawater pumps shall be submersible. The pump material in contact with the liquid shall be Superduplex stainless steel with PREN < 40, with cathodic protection to prevent corrosion.

The regular method to pump raw water shall be with four groups in simultaneous operation. The operational program shall function in a manner to allow all groups to work the same number of hours, alternating at the reserve pump stops.

#### 5.4.1.3. Brine discharge

The discharged brine resulting from the process will be discharged back to the sea through a discharge tube composed of a high-density polyethylene (HDPE) tube with a 1,200 mm diameter.

#### 5.4.1.4. Chemical Pretreatment

**Pretreatment Sodium Hypochlorite Dosage**

The sodium hypochlorite dosage is projected to perform offline seawater shock dosing.

For this purpose, two GRP hypochlorite tanks, each with 12 $m^3$ capacity, equipped with a level measurement device, high and low-level switches, drainage, interconnection tubes and other accessories were provided.


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The hypochlorite injection into the collection water is performed by three metering pumps (2 + 1), one of which is a reserve, of the positive displacement type. The pump materials are as follows: PVC body and boxes, polyethylene seats, PTFE membranes, viton seals and casting crankcase. The pumps' nominal flow is adjustable between 10% and 100%; regulation is automatic, with control panel operation, for which the metering pumps will be supplied with the corresponding servomotors.

Since hypochlorite shock dosing is projected, a 10-ppm dose of active chlorine was established for the project.

To fill the tank, a centrifugal transfer pump with 90 $m^3$/h flow shall be installed.

The hypochlorite dosing lines must be made of PVC-U.

The sodium hypochlorite dosing system shall be located in a basin with sufficient capacity to store all its contents, plus an additional 10%.

**Sulfuric Acid Dosage**

A sulfuric acid dosing system has been provided for CIP osmosis cleaning. The addition of sulfuric acid to seawater is also projected to facilitate hypochlorite disinfection and adjust dispersant addition.

The sulfuric acid equipment shall consist of two 12 $m^3$ storage tanks, made of carbon steel and equipped with a level indicator, level transmitter, level switches, drains, ventilation and silica gel air-drying system and other accessories.

A centrifugal pump with 60 $m^3$/h flow shall be installed for the transfer of sulfuric acid from the transportation medium to the storage tanks.

For the acid dosage in seawater, three (2 + 1) dosing pumps shall be installed, one of which shall be a reserve.

The pump material shall be as follows: AISI 316 body and valve boxes, PTFE membranes and gaskets, Hastelloy C balls, AISI 904 seat, and cast iron crankcase. The pumps are of the positive displacement type, adjustable from 10% to 100% and equipped with servomotors for control regulation.

A shower with an eye wash station shall be installed as a safety and protection measure.

The sulfuric acid dosing system will be located inside a pan coated with antacids, with sufficient capacity to store its entire contents, plus an additional 10%.

The sulfuric acid dosing tubes shall be made of carbon steel.

**Sodium Metabisulfite Dosage**

A sodium metabisulfite dosing system was designed to reduce residual chlorine before the seawater reaches the membranes, given their low tolerance to chlorine. This substance reacts with chlorine and other oxidants contained in seawater, such as dissolved oxygen, preventing them from reaching and damaging the membranes.

In addition, sodium metabisulfite shall be added to the brine tank, if necessary.

The equipment consists of two GRP 1000-liter capacity accumulation-dissolution tanks, equipped with electric agitators, isolation, safety and check valves, interconnection tubes, accessories and the corresponding 2 + 1 metering pumps, one of which is a reserve.



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The use of two tanks for reagent dissolution facilitates the plant's operation, as one tank can work while the metabisulfite solution is prepared in the other.

The storages shall be equipped with local levels, level transmitters and high and low-level alarms. The electric agitator shafts and blades shall be of AISI 316 stainless steel.

The product shall be added before the cartridge filters' inlet, to provide the maximum possible contact with the chemical reagent. In addition, an additional injection point shall be installed after the cartridge filters.

The pump material shall be as follows: PVC body and boxes, polyethylene seats, PTFE membranes, viton gaskets and cast iron crankcase.

They shall be adjustable from 10% to 100% of their maximum capacity. Regulation will be automatic from the panel that shall supply each pump, with its corresponding servomotor.

After this equipment and the cartridge filters, there shall be an ORP sensor with alert recording and panel, a pH meter with panel display and maximum and minimum alarm, with registration. This equipment is to ensure that no oxidants reach the RO membranes.

The sodium metabisulfite dosing system shall be located inside a tank with sufficient capacity to store all its full capacity, plus an additional 10%.

The metabisulfite dosing pipes shall be made of PVC-U.

**Ferric Chloride dosage**

For the elimination of seawater suspended matter and colloids, a ferric chloride dosage shall be executed. The equipment was projected for a dose of 5 mg/L.

There shall be two GRP accumulation tanks, each with a 30 m³ capacity. The tanks shall be equipped with local level indicators and a level transmitter, as well as provide high and low-level alerts.

The ferric chloride deposits shall be located in a tank with sufficient store capacity for its whole content, in case of breakage.

There shall be three metering pumps (2 + 1), one of which shall be a reserve. The pump material shall be as follows: PVC body and boxes, polyethylene seats, elastomeric PTFE membranes, viton gaskets and a casting crankcase. They shall be adjustable from 10% to 100% of their maximum capacity. Doser regulation shall be automatic from the control panel from which they are supplied, with the corresponding servomotors.

The ferric chloride deposits will be located in a tank with sufficient capacity to store its entire content in case of breakage.

For the transfer of ferric chloride from the transportation parts to the storage tanks, a centrifugal transfer pump with a flow of 60 m³/h shall be installed.

The ferric chloride dosing system shall be located in a tank with full storage capacity for its entire content, plus 10%.

The coagulant dosing tubes will be PVC-U.

**Dispersant Dosage**


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When seawater is concentrated in the membranes, to avoid precipitation from calcium sulfate, strontium sulfate and calcium fluoride salts, among others, a dispersant shall be injected in a dose of 1 mg/L. Its function is to prevent the formation of crystalline salt networks, maintaining ions in dispersion and allowing the solubility limit of said salts to be exceeded.

The equipment consists of two GRP accumulation-dissolution tanks of 1000-liter capacity, which shall aspirate the dosing pumps.

There shall be three metering pumps (2 + 1), one of which will be a reserve. The pump material shall be as follows: PVC body and boxes, polyethylene seats, elastomeric PTFE membranes, viton gasket and casting crankcase. They shall be adjustable from 10% to 100% of their maximum capacity. Doser regulation shall be automatic from the control panel from which they are supplied, with the corresponding servomotor.

The product is added online and before the cartridge filters to provide the maximum contact time possible. An additional dispersant dosing point shall be installed before the filtered water inlets to the cartridge filters.

The dispersant dosing system shall be located inside a tank with sufficient capacity to store its full capacity, plus 10%.

The ferric chloride dosing pipes shall be of PVC-U.

**Activated Carbon Powder Dosage**

A powder activated carbon dose in included in the project. The activated carbon shall be stored in a 1 $m^3$ capacity silo. Two injectors shall deliver it for the preparation of a solution with service water, which shall be performed in two GRP tanks with a 1000 L capacity each. Each tank shall be equipped with an electric agitator, isolation, safety and check valves, indicator, maximum and minimum level switch with alarms, interconnection tubes and accessories.

This active carbon solution dosage shall be performed by three metering pumps, one of which is a reserve. The pump material shall be the following: PVC body and boxes, polyethylene seats, elastomeric PTFE membranes, viton gaskets and cast iron crankcase. These will be adjustable from 10% to 100% of their maximum capacity. The pump materials will be followed by: PVC boxes, polyethylene seats, elastomeric PTFE membranes, viton gaskets and cast iron crankcase. These will be adjusted from 10% to 100%, given their maximum AISI 316 capacity.

The active carbon metering system shall be installed inside a secondary container with sufficient capacity to contain its full volume + 10%, in case of breakage.

The active carbon metering system pipes shall be made of polypropylene.

The activated carbon metering system shall be located inside a bucket with full storage capacity, plus 10%.

The active carbon dosing pipes shall be made of PVC-U.

### 5.4.1.5. Physical Pretreatment

**Closed Pressure Filters**

For the elimination of particles present in raw water, seawater shall be filtered through two stages of sand and anthracite filters, as a filter medium in the appropriate proportion.


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The first stage consists of 14 horizontal cylindrical filters that shall be arranged in parallel, so that the flow is distributed among them in the normal operation process. Each filter houses a support plate equipped with the corresponding nozzles in which the sand filter bed is placed.

The filters shall be built in FRP with a chemical barrier of isophthalic resin or ST 44/2 quality carbon steel or similar, and internally coated with a 3 mm thick layer of neoprene or natural rubber, applied by autoclave. The filters shall be externally painted with UV resistant paint. The filter arrangement shall be horizontal cylindrical, pumped at the bottom.

Once a filter's flow drops below 80% of normal operation, it shall be backwashed through the passage of operational flow by other filters in service.

The filters shall have a 4 m diameter and 24 m cylindrical length, which is equivalent to an effective filtering surface of 88.43 $m^2$ per filter. Maximum filtration speed shall be 6.5 m/h, and 7 m/h during filter washing. The filters will be equipped with the manholes necessary for inspection and maintenance. They shall also transport drains, vents and corresponding equipment, as well as the set of automatic valves necessary to carry out fully automated washing and commissioning operations.

If the operator so wishes, washing can be done semi-automatically, where each of the steps to be performed can be selected from the panel. It is also possible to change washing stage times, operate programming levels and change the washing system.

The filter nozzles are projected to avoid filter leakage and maintain the pressure drop to a minimal. There is a total of 50 nozzles installed per square meter of filtering surface. The nozzles are made of plastic resistant to and not degradable by seawater.

The filters will have 3 filter layers with the following characteristics:

- ✓ 1st layer:

| | |
|---|---|
| Material | Anthracite |
| Layer height | 0,7 m |
| Material effective size | 1,9 mm |
| Uniformity coefficient | 1,4 |
| Material cutoff point | 226 micra |

- ✓ 2nd layer:

| | |
|---|---|
| Material | Silex |
| Layer height | 0,4 m |
| Material effective size | 0,6 mm |
| Uniformity coefficient | 1,45 |
| Material cutoff point | 93 micra |

- ✓ 3rd layer:

| | |
|---|---|
| Material | Silex |
| Layer height | 0,2 m |
| Material effective size | 2,0 mm |
| Uniformity coefficient | 1,7 |
| Material cutoff point | 309 micra |



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The second stage shall consist of eight horizontal cylindrical filters that shall be arranged in parallel, so that the flow is distributed among them in the normal operation process. Each filter will house a support plate equipped with the corresponding nozzles, in which the silicon filter bed is placed.

The filters shall be built in FRP with a chemical barrier of isophthalic resin or ST 44/2 quality carbon steel or similar, and internally coated with a 3 mm thick layer of neoprene or natural rubber, applied by autoclave.

The filters shall be externally painted with UV resistant paint. The filter arrangement shall be horizontal cylindrical with pumping at the bottom.

Once the passing flow through a filter drops 80% from its normal work flow, it shall be washed by the passage of work flow through the other filters in service.

The filters are 4 m in diameter and 24 m in cylindrical length, equivalent to an effective filtration surface of 88.43 $m^2$ per filter. Filtration speed in normal operation is 10.8 m/h, and a maximum of 12.4 m/h in a washing situation. The filters shall be equipped with the manholes necessary for inspection and maintenance, which shall transport drains, vents and the corresponding instrumentation, as well as the set of automatic valves necessary to carry out washing and commissioning operations in full-automatic mode.

If the operator so wishes, washing can be done semi-automatically, where each of the steps to be performed can be selected from the panel. It is also possible to change washing stage times, operate programming levels and change the washing system.

The filter nozzles are projected to avoid filter leakage and maintain the pressure drop to a minimal. There is a total of 52 nozzles installed per square meter of filtering surface. The nozzles are made of plastic resistant to and not degradable by seawater.

The filters shall present 2 filtrating layers with the following characteristic:

| | |
|---|---|
| ✓ 1st layer: Material | Silex |
| Layer height | 0.5 m |
| Material effective size | 0.3 mm |
| Uniformity coefficient | 1.4 |
| Material cutoff point | 46 micra |
| ✓ 2nd layer: Material | Silex |
| Layer height | 0.2 m |
| Material effective size | 2.0 mm |
| Uniformity coefficient | 1.7 |
| Material cutoff point | 309 micra |

Samples will be installed to measure the water's SDI before and after each filtration stage, to determine filtration efficiency and water quality before it enters the membranes.

**Closed Pressure Filter Washing**

The filters shall be washed with membrane reject water (brine). For this, three centrifugal pumps (2 + 1R) will be available, one of which is a reserve pump. The set of washing filters shall be placed in the process device.



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The pump flow shall be 1,914 $m^3/h$ at a discharge pressure of 2.3 bar. The material composing the body, rotors and shaft must be made of PREN > 40 superduplex quality steel. The use of membrane reject water for washing saves energy and chemical products.

In addition to washing water making use of the pumps described, three fans (2 + 1R) of 2,211 $Nm^3/h$ will be available, one in operation and the other in reserve. The inclusion of blowers helps guarantee an efficient washing, as well as a remarkable saving of washing water. The blowing unit has its corresponding air filter, noise silencer, safety and isolation valves, as well as pipe sections with corresponding pressure gauges and accessories. The water and air washing pipe shall be made of glass fiber reinforced polyester.

The washing water flow shall be controlled by a valve located in the washing water filter collector, only during discharges from the washing water pumps. To measure washing water flow, a flow meter installed in the pump discharge manifold will be available.

Filter displacement, after brine washing, shall be carried out with seawater driven by seawater pumps, and the displacement flow shall be controlled by a control valve.

The first and second stage filters shall not be washed simultaneously.

**Cartridge filters**

The filtering process shall consist of 8 cartridge filters, embedded in GRP.

The cartridge filters shall be equipped with polypropylene depth filtration cartridges with a cut-off point rating of 10 absolute and 5 nominal microns, with a particle removal efficiency of 99.6% and a beta ratio of 5,000.

Before and after the cartridge filters, sample sockets will be installed to measure the water's SDI, to determine filtration efficiency and water quality before entering the membranes.

The pipes and filter inlets and outlets shall be made of PN-10 glass fiber reinforced polyester.

### 5.4.1.6. Reverse Osmosis

The proposed project corresponds to an osmosis stage with a 45% conversion in four project production lines of 21,665 $m^3/h$.

The seawater assessment used to perform membrane projections differs from the raw water analysis shown in the initial data section. The difference between the two analyses is that the membrane water analysis contemplates not only the chemical pretreatment, described in previous sections, but also the mixture of seawater and brine in the pressure exchange systems. The use of pressure exchange systems causes an increase in seawater salinity at the RO system inlets. For these reasons, the method used to perform membrane projections shows a higher concentration of dissolved salts than the one used for the project's raw sea water. The Figure below shows the seawater analysis method used in membrane projections.



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**ANALISE DA AGUA BRUTA PARA DESENHO DAS MEMBRANAS**

| ANÁLISE FISICO-QUIMICO | | | | | |
|---|---|---|---|---|---|
| TURBIDEZ | 0,0 | U.N.F. | PH | 7,22 | |
| COR | 0,0 | Pt-Co | CONDUTIBILIDADE | 60.269,17 | µmhos/cm. |
| ODOR | 0,0 | TON | T.D.S. | 40.152,66 | mg/L |
| ASPECTO | | | ALCALINIDADE | 125,51 | ppm CO3Ca |
| TEMPERATURA | 27 | ºC | DUREZAE | 6.583,44 | ppm CO3Ca |
| **COMPOSIÇÃO IONICA** | | | | | |
| **ELEMENTO** | **mg/L** | **meq/l** | **ELEMENTO** | **mg/L** | **meq/l** |
| Ca++ | 518,72 | 25,88 | SO4= | 4.283,64 | 89,19 |
| Mg++ | 1.284,51 | 105,67 | Cl- | 21.002,11 | 592,39 |
| Na+ | 12.450,74 | 541,55 | CO3H- | 148,43 | 2,43 |
| K+ | 431,80 | 11,04 | F- | 0,31 | 0,02 |
| Ba++ | 0,02 | 0,00 | Br- | 0,00 | 0,00 |
| Sr++ | 5,24 | 0,12 | I- | 0,00 | 0,00 |
| Fe++ | 0,00 | 0,00 | NO2- | 0,00 | 0,00 |
| NH4+ | 0,31 | 0,02 | NO3- | 11,00 | 0,18 |
| Ag+ | 0,00 | 0,00 | CO3= | 2,26 | 0,08 |
| Mn++ | 0,00 | 0,00 | PO4= | 0,00 | 0,00 |
| Zn++ | 0,00 | 0,00 | S= | 0,00 | 0,00 |
| Cu++ | 0,00 | 0,00 | SiO2 (coloidal) | 0,04 | 0,00 |
| Al+++ | 0,00 | 0,00 | SiO2 (soluble) | 8,43 | 0,14 |
| Fe+++ | 0,00 | 0,00 | CO2 | 5,99 | 0,14 |
| H+ | | 0,00 | OH- | | 0,00 |
| **TOTAL** | **14.691,34** | **684,28** | **TOTAL** | **25.456,18** | **684,28** |

| OUTRAS DETERMINAÇÕES | | | |
|---|---|---|---|
| **SUBSTÂNCIAS TOXICAS** | **mg/L** | **Matéria orgânica e outros** | **mg/L** |
| Arsênio | 0,00 | DBO5 | 0,04 |
| Cádmo | 0,00 | DQO | 0,10 |
| Bário | 5,14 | Nitrogêno proteico | 0,00 |
| Mercurio | 0,00 | Compostos fenólicose | 0,00 |
| Chumbo | 0,00 | Detergentes | 0,00 |
| Selênio | 0,00 | Oleos e graxas | 0,00 |
| Cromo total | 0,00 | Hidrocarbonetos | 0,00 |
| Cromo | 0,00 | Sólidos em suspensão | 0,21 |

To determine the production of the osmosis process, membrane projections were made for the two temperatures (22ºC and 30ºC) in the project, with clean and dirty membranes for both temperatures. The membrane projections are displayed in Attachment 14.3. The project was carried out considering the worst conditions for the membrane projections, both in pressure and water quality, so that the correct operation is guaranteed over the entire temperature range and for any membrane condition.

The project was carried out considering lower permeate flows and higher rejection rates, which could create excessive fouling problems, especially in the first and last membrane modules.

The flow design is shown below.



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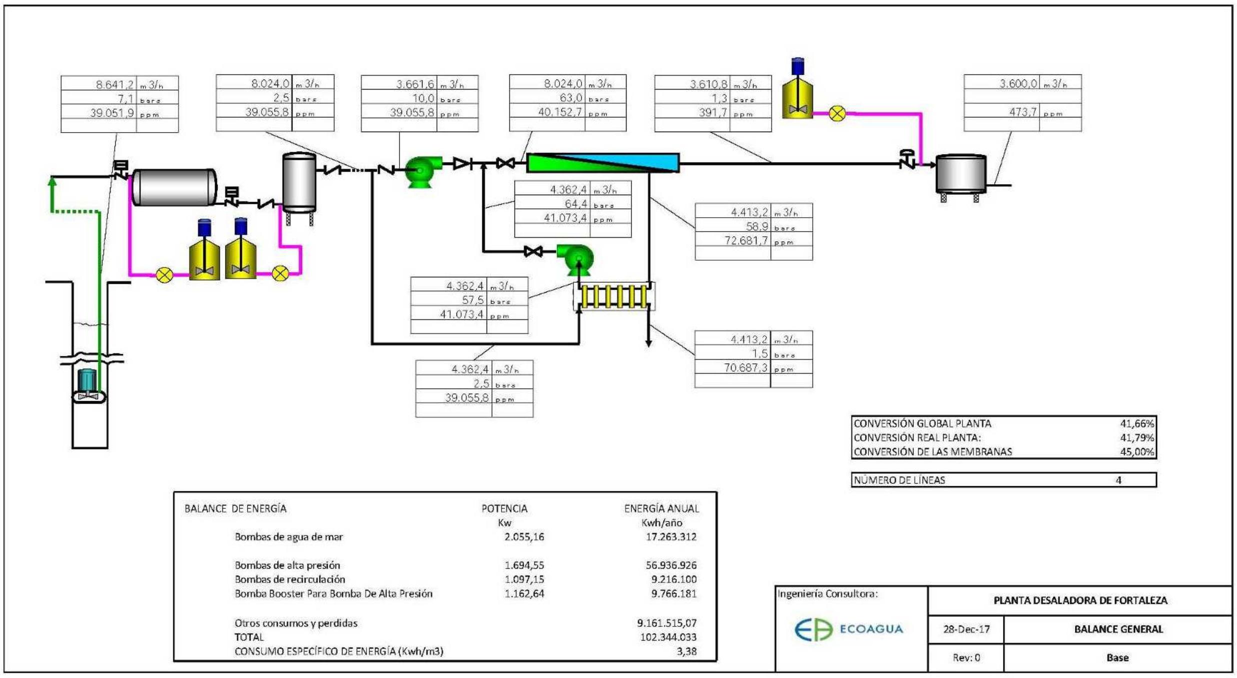


**High-pressure pumping, booster pumping, recirculation pumping and energy recovery.**

The high-pressure pumping system has the fundamental mission of providing the pressure necessary to overcome the osmotic seawater pressure and system pressure losses.

A group of motor pumps will be installed for each frame. The high-pressure pumps shall be high performance, made of PREN > 40 Superduplex quality steel.

The high-pressure pumping system consists of 04 units of centrifugal pumps with 915 m³/h of unitary capacity and a TDH = 542.6 mcl.

Four booster pumps will also be installed for high-pressure pumps, with a speed variation of 915 $m^3$/h and TDH = 83.37 mcl, with materials of identical quality used for the booster pumps and the high-pressure pumps.

To recover energy from the brine rejected from the first stage, pressure exchange systems (PES) will be used, as they present the best performance in terms of energy recovery on the market. In this case, each line shall be composed of a pressure exchange system that will be consist of 18 exchangers. One of the exchangers will be a backup, even if it is in normal operation, because if one of the 18 exchangers stops working, the system can continue working with 17 without a problem.

In the brine feed collector outlet to the PES, there will be a pressure transmitter and a conductivity meter. A flow meter and a pressure transmitter shall be installed in the low-pressure seawater inlet for the energy recovery systems. The seawater, at the PES outlet, will have acquired a pressure of 57.5 bar, when entering the recirculation pumps suction. A flow meter, a conductivity meter and a pressure transmitter shall be installed at the suction portion of the recirculation pumps.

At the outlet of the energy recovery systems, four recirculation pumps will be installed and equipped with a speed variator, which shall increase the seawater outlet pressure from the PES until the required membrane inlet pressure is reached. The materials used in the recirculation pump shall be equal to those of the high-pressure pump. These pumps will be of high performance and have a unit flow of 1,090.6 m³/h with a TDH of 68.5 mcl.


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The high-pressure pumps suction tubes must be made of glass-fiber reinforced polyester. The pump discharge pipes, the energy recovery system inlets and the recirculation inlet and outlet pumps must be made of Superduplex PREN > 40 quality steel.

At the suction of each high-pressure motor group of the pump, there will be a low-pressure switch that will produce an alert and register in the control system, stopping the low suction pressure pump. Likewise, a seawater flow transmitter shall be placed at the pump's suction, to record and issue alerts resulting from the pump's eventual low flow production.

A pressure gauge, a check valve, an automatic valve and a pressure transmitter will be available when operating high-pressure pumps.

At the recirculation pump discharge outlet, a pressure transmitter, a check valve and a motorized valve will be installed. This pump's operation will be set off by the high-pressure pump's operation, before it is sent to the Reverse Osmosis' first step inlet.

Regulation of the total seawater flow from the structure's feed shall be carried out by the feed pump to the high-pressure and the recirculation pumps, and for this each pump motor shall be equipped with a speed variator.

The flow meter and conductivity meter sets shall be used to control the operation of energy recovery systems and energy recovery efficiency.

The roller bearings in all pumps, as well as motor windings, shall have temperature probes.

**Reverse Osmosis Racks**

The Reverse Osmosis process consists of 4 membrane lines of one stage each. Each line contains 12 rows and 20 columns, where 226 pressure vessels will be installed, leaving 14 free spaces for the tubes. Each tube has the capacity to accommodate 7 membranes, so the total number of membranes installed shall be 1582. The membranes shall be fed by horizontal tubes shared by two rows of membranes. Two vertical collectors will supply all horizontal tubes.

The plant was designed considering the installation of aromatic polyamide spiral wound membranes with a 99.75% salt rejection, with 440 feet of active membrane area, and system flow less than 14 lmh.

Seven membranes of this type shall be arranged by container or pressure vessel. The pressure vessels shall be made of GRP, of a brand known and tested in similar plants, and projected according to ASME X. The seawater and brine connections will be multiport.

All pressure vessels shall be installed in a carbon steel structure, painted with epoxy and capable of bearing 230 pressure tubes.

The permeate obtained in each pressure vessel shall be taken to a horizontal collector that transports permeate water to the vertical collectors. The vertical collectors shall be located on the opposite side of the seawater supply connections to the pressure vessels.

Finally, the permeate will be sent to the general collector that will transport it to the product water reservoir, having previously passed through the post-treatment.

A system will be installed to perform a flow measurement at the permeate outlet of each pressure vessel. In addition, the salinity of each membrane in the pressure vessels shall be sampled by the


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introduction of a sampling pressure vessel. These measures shall elucidate the operation status of the membranes installed in the pressure vessels and interconnectors.

On the other hand, a permeate sample shall be installed for each pressure vessel, which shall be taken to a general sampling panel. This panel is to be installed on a side of the corresponding line. Through this panel and quick connections, it will be possible to obtain a measurement of the permeate water quantity conducted by each pressure vessel, a parameter indicative of membrane deterioration or incrustation status.

The RO supply pipes shall be made of PREN > 40 Superduplex stainless steel. The brine outlets shall be made of the same material. The permeate collectors, the pressure tube permeate connectors and the permeate piping shall be made of GRP or PP (depending on the diameter), until they reach the product water tank collector.

The connectors between the pressure pipes and their respective seawater and high-pressure brine pipes shall be of the Victaulic type. The permeate connectors must be screw threaded.

**Chemical Cleaning and Membrane Displacement Equipment**

When considerable membrane contamination happens, or membrane chemical cleaning is necessary due to of pollution from the raw seawater, this equipment shall be used. The equipment consists of a 110 m³ accumulator tank in which the appropriate reagent dissolves, in permeate water from the permeate tank, to eliminate the dirt produced. Agitation will be performed by two agitator pumps. The cleaning tank will be equipped with an electric resistance heating element, a temperature gauge and an alarm for maximum and minimum levels. The reservoir shall be built in GRP.

Once the chemical cleaning solution has been made, it will be aspirated by two centrifugal pumps that will send it to one of the osmosis structures, for the chemical cleaning of its membranes. Two centrifugal chemical cleaning pumps shall be installed. The pump materials in contact with water will be made of AISI 316. The pumps shall have isolation and check valves, manometers and GRP interconnection tubes, as well as a flow meter.

The chemical solution will pass through a cartridge filter before it reaches the line, to eliminate small reagent particles that remain undissolved. This filter is the same type as those used in seawater pretreatment, and the filter cartridges shall be interchangeable with those of pretreatment. The filter is equipped with isolation valves and inlet and outlet pressure gauges.

The solution shall be introduced into the feed tube of the corresponding structure, behind its isolation valve, which at this time shall be closed. It passes through the pressure vessels cleaning the membranes at low pressure, and most of the solution will be reject from pressure vessels with dissolved precipitates and small particles that it drags, the dirt from the membranes. This outlet solution is transported back to the cleaning tank.

The permeate line shall leave behind a small amount of chemical solution through a vessel facing the cleaning tank, as a reject, forming a closed cleaning circuit.

When carrying out chemical cleaning, the structure’s closed circuit and the cleaning equipment must be isolated, so that valves with limit switches and accessories are available for this purpose.

Periodic cleaning of the membranes is a necessary process for their preservation, as well as the proper process operation.


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The chemicals to be used in membrane cleaning are various and depend mainly on two factors, which are the type of dirt that has occurred and the type and manufacturer of membranes installed. Therefore, the concrete instructions and products to be used shall be defined in the construction and test phases, according to the selected membrane manufacturer.

Whenever there is a prolonged stop in any of the Reverse Osmosis lines, it is necessary to displace the seawater and brine with permeate in the high-pressure pumps, recirculation pumps, pressure exchange systems, piping, pressure vessels and membranes. If rinsing is not carried out, the pumping equipment and pipes may be corroded and precipitation may occur in the membranes, leading to significant fouling.

The permeate water destined for this process shall be taken from the permeate water reservoir.

A centrifugal pump with the same characteristics as chemical cleaning pumps shall be used for displacement. The displacement pump and chemical cleaning pumps’ suctions will be connected to the cleaning and permeate tanks.

The permeate water tank will made of GRP and have a 200 $m^3$ capacity for permeate water. It will be equipped with high and low-level floats, a level transmitter, overflow tubes, drain and permeate water inlet and outlet.

The injection of rinse water in treatment lines is verified in the high-pressure pump and in the recirculation pump suctions, with closing of the corresponding automatic valve in the main line and opening of the access valve to the main line, for the displacement of the line subject to this process.

The mixture of sea water and/or brine with backwashing water will flow from the pressure exchange systems’ brine tube to the facility’s general drain. The washing process will end when outlet water conductivity is less than 2000 ohms/cm.

#### 5.4.1.7. Post-treatment

The permeate water at the osmosis rack outlets will be treated through a series of post-treatment processes to achieve quality conditions required, in terms of pH, Langelier Index, chlorine and fluoride levels.

Post-treatment shall consist of the following treatments: $CO_2$, calcium hydroxide, sodium fluorosilicate and sodium hypochlorite dosages.

**$CO_2$ Dosage**

The $CO_2$ dosing equipment consists of two 40-ton capacity storage tanks. The $CO_2$ shall be stored in liquid form in insulated tanks at –20°C/20 Kg/cm². The storage tank shall be equipped with all level, pressure regulation and safety control devices.

Starting from the tank, liquid $CO_2$ will be decanted, vaporized and brought to room temperature by an electric evaporator. The $CO_2$ storage tank and vaporizer assembly will be located in an open, fenced compartment.

The vaporized $CO_2$ shall be connected to the corresponding control panel to allow carbon dioxide expansion, measurement and regulation based on $CO_2$ dosage flow and the pH of the water to be treated. The control equipment shall consist of an extended steel gas pipeline, valves, expansion reducer, rotameter flow meter, regulating valves, manifold, injection valves, pH meter and $CO_2$


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injection system. The $CO_2$ shall be injected into the permeate water tube before the calcium hydroxide dosage.

**Calcium Hydroxide Dosage**

The planned facility for the calcium hydroxide dosage system consists of:

- ✓ Two silos, with a volume of 100 m³ and an agitation system, for calcium hydroxide storage.
- ✓ Two calcium hydroxide screw feeders with a frequency variator, to regulate the amount of lime to be added to the sludge preparation tank, according to the permeate flow obtained.
- ✓ Two tanks for the preparation of lime slurry with a 7.10 m3 capacity, to prepare calcium hydroxide at a concentration of 50 g/L continuously, equipped with an electric mixer.
- ✓ 4 + 1 feed lime metering pumps

**Sodium Fluorosilicate Dosage**

Sodium fluorosilicate dosing is projected to comply with the fluoride content regulation for drinking water.

For this purpose, two fluorosilicate tanks of 1 m³ each in capacity, built in GRP, equipped with level transmitters, high and low-level switches, drainage, interconnection tubes and other accessories shall be provided.

The fluorosilicate injection is performed by three metering pumps (2 + 1), one of which is a reserve, of the positive displacement type. The pump materials are as follows: PVC body and boxes, polyethylene seats, PTFE membranes, viton seals and casting crankcase. The pumps' nominal flow of the pumps is adjustable between 10% and 100%; regulation is automatic, with operation from the control panel, for which the metering pumps will be supplied with the corresponding servomotors. The elected pipes for fluosilicate dosage are made of PVC-U.

**Sodium Hypochlorite Dosage**

Two GFRP 1 $m_3$ tanks are provided for post-treatment hypochlorite dosing, with level transmitter, high and low-level alarms and other accessories.

The hypochlorite injection in the water is performed by three metering pumps (2 + 1) of the positive displacement type. The pump materials are as follows: PVC body and boxes, polyethylene seats, PTFE membranes, viton seals and casting crankcase. The pumps' nominal flow is adjustable between 10% and 100%; regulation is automatic, with control panel operation, for which the metering pumps will be supplied with the corresponding servomotors. The hypochlorite dosing pipes adopted are made of PVC-U.

### 5.4.1.8. Complementary Services

**Instrument and Service Air System**

Both proportional and complete opening control valves (on/off) shall be supplied with an electric drive, so that the air system is assigned only for instrumentation and services.

Two air compressors for instruments and services will be installed, with a compressed air tank and air cooling, oil separator, automatic purging and dryers. It shall be a double-acting compressor, or threaded with oil, and work at 8 $Kg/cm_2$ of pressure. It will have an accumulation tank.

The compressors will operate in the following manner:



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- ✓ The compressor automatically enters the load when the predetermined low air pressure is reached.
- ✓ The compressor stops automatically when the predetermined high pressure in the accumulator is reached.

The project previews the installation of an instrument and service air system that reaches the necessary points, installing the traps and other accessories necessary for correct facility operation.

**Service Water System**

To supply service water at the plant, a pressure group consisting of a 10-bar pressurized accumulation tank, with 4 $m^3$ capacity, AISI 316 L steel parts in contact with water and two (1 + 1) multicellular pumps will be installed. Each pump shall have a flow of 10 $m^3/h$ at a 6-bar pressure and be built in AISI 316 L. A service water network built in HDPE shall be available throughout the factory.

**Elevation and transport equipment**

For the maintenance operations of high-pressure motor pumps, booster pumps and BAP pump recirculation, an overhead crane will be mounted in the Process Building and with a full-length trajectory to reach all this equipment.

For seawater pump maintenance operations, a bridge crane will be installed in the Intake Building, extending to the pumps' full length.

In addition, a winch will be installed to exchange filter cartridges as needed.

**Stairs and platforms**

The necessary platforms and ladders shall be available to access all elements of operation, measurement and control, such as equipment, instruments, valves and others. In particular, any facility site that must be periodically visited by maintenance or operating personnel must have easy and safe access.

The stairs shall have handrails on both sides in places that require it. The platforms must have rails with a minimum height of 1.1 meters, incorporating the elements necessary to make it removable for maintenance, in areas that require it. Air duct intersection, with headroom less than 2.00 m, will be avoided. Stair and handrail structures can be made of FRPV, painted steel or AISI-316.

The Tramex platforms and trays will be made of polyester, galvanized steel or stainless steel and will be divided into sections to allow their disassembly for maintenance.

All necessary supports and fasteners shall be available. All elements will be designed to support the weight of operators, tools and parts of the installation that may be placed during assembly, maintenance and periodic assessments.

**Fire-fighting system**

The fire system shall be composed of fixed fire extinguishers, strategically located on the premises and complemented with portable fire extinguishers in sufficient quantity and quality to attack the fires that could take place.

In addition, the facility shall have a detection system, which shall basically consist of monitoring and central control. This panel contains different manual buttons, alarm bells and detectors. The latter



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shall be appropriate type, according to placement and the quality to be monitored (smoke, gases, flames or heat), to guarantee maximum speed in the detection of a possible fire. The aforementioned shall comply with applicable laws and industry requirements.

**Brine discharge**

The brine reject from the membranes, after passing through the pressure exchange system, shall be sent to the brine tank and from there to the sea, through the outfall.

**Laboratory e workshops**

The laboratory and workshops will have the necessary equipment and instruments for correct process supervision and control.

**Replacement parts**

Recommended replacement parts for one year of operation are included.

### 5.4.2. Effluent and Waste Management

The pre-treatment selected, with a double filtration stage, uses brine generated in the osmosis process to backwash the filters. In this manner, the energy needed to produce more filtered sea water that would be used to backwash the filters is reduced. In addition, brine controls bacterial loads on the filter beds, by creating salt stress over the microorganisms present.

Once the brine wash cycles are finished, before the filter is put back in service, it is necessary to remove the brine from their structure. For this, the filter is put in filtration mode, to be filled with seawater and discharge filtered water (mixture of brine and seawater) into the brine storage tank that was used in the filter washing process.

Each filter washing cycle generates a volume of brine loaded with the solids retained in the filter, and another from the seawater and brine mixture (until it is completely disposed); its solid content is low, since the water discarded would be filtered and the brine used for washing would also be free of solids.

The washing water does not contain chemicals, and the solids removed from the filters are those that normally contained in seawater. Eventually, there may be smaller amounts of ferric chloride (used as a coagulant) at the filter inlets, to improve filtered water quality.

It is a common practice to mix these waters with the brine produced and discard the mixture into the sea through a brine discharge pipe. In accordance with existing legislation or EIA recommendations, it is possible to incorporate a system to separate washing water solids to reduce its concentration at discharge.

The chemical products suggested to wash the reverse osmosis membranes are acidic or alkaline formulations with detergents or dispersants, made to eliminate solid deposits on the membranes.

The options elected in this case will be previously neutralized in the chemical cleaning deposit and CIP, before being transported to the brine discharge tank.

A recirculation pump draws water from that tank and returns it to the same tank. A pH and a Redox meter shall be placed at the suction pipe to control chemical dosing in the recirculation pump discharge pipe, until the pH and Redox potential are equal to those of seawater.



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After several minutes with a stable pH and Redox potential, within the limits established by the environmental agencies, a set of valves allows the tank to be emptied into the brine pond and then discharged into the sea.

The effluent treatment systems shall be executed in the following manner:

- ✓ The neutralization of cleaning chemicals neutralization shall be performed in the same tank.
- ✓ The water mixture from the closed filter brine backwashing, before being discharged into the sea by the submarine outfall, must have its concentration of suspended solids reduced to comply with current legislation. The normal suspended solid values that can be found in seawater when adopting an intake system as proposed in the present study ranges from 10 to 15 ppm. Studies show that with a higher intake of solids, 20 ppm, the concentration of solids in brine discharge would be 35.5 ppm. These solids, like dissolved salts, would be quickly dispersed in the sea without major impacts on the marine environment. The final process definition will depend on the recommendations made by the environmental agency (SEMACE), at the time of environmental licensing. Depending on the analysis and the requirements of the environmental agency, an additional washing water treatment may be deemed necessary.
- ✓ It is important to highlight that in none of the desalination plants operated by GS INIMA there was a request from environmental agencies for the installation of equipment for the treatment of brine used to wash sand filters.
- ✓ Plant drains will be conducted to the brine tank for the discharge section, where a sodium metabisulfite dose shall be injected to neutralize the chlorine possibly contained in the drains.
- ✓ Industrial waste: oils, solids, chemicals and others that will be properly classified and taken to companies authorized for their collection, treatment and final disposal.
- ✓ Wastewater treatment: considering a water consumption of 150 L/person/day, a maximum of 40 people and that 80% of the total water consumed will result in treatable wastewater, during the operational phase of Project 4, 8 $m^3$/day of treatable wastewater shall be generated. The content from the sanitary sewer networks shall be sent by gravity to the public sewage collection network in the plant's vicinity, assuming there is a connection to this network. If it does not exist, it will be necessary to install a pumping well with submersible pumps at the lot entrance, to direct the sewage to the public network, according to NBR 8160/99 requirements.


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# 6. Civil Construction

## 6.1. Introduction

This document presents the calculation assumptions and premises considered for this reference project.

This project includes the following specialties:

- ✓ General installation infrastructures:
  - Landscaping;
  - Drainage;
  - Pavement;
  - Landscape integration;
  - Outdoor lighting network.
- ✓ Building architecture (described in Chapter 8);
- ✓ Building and processing branch structures;
- ✓ Building’s water network:
  - Potable Water Supply Network;
  - Domestic Sewer Collection Network;
  - Rainwater Drainage Network.
- ✓ General Electrical Grid:
  - Normal lighting;
  - Safety lighting;
  - General use power outlets;
  - Grounding system;
  - Switchboards;
  - Safety installations;
  - Telecommunication;
  - Fire detection and fire extinguishing systems.

The installation shall consist of the following main structures:

- ✓ Intake Tower – structure in the high seas where seawater is collected, then guided by a submerged pipeline to the Collection Chamber;
- ✓ Collection Chamber – buried at a depth of about 24.00 m, this chamber serves to install the pumps that will pump the water collected from the sea. Next to this Chamber there is a first phase of water disinfection;
- ✓ Filtration – 1st and 2nd phases – composed by high cylindrical tanks, it is in this zone that the finer particles are retained with sand;
- ✓ Process Building – this building houses most of the process equipment, namely the osmosis pumps and filters, as well as the remineralization phase;
- ✓ Administrative Building – situated next to the Process Building, it shall serve as support and process control, containing the Transformation Post, Painting Room, Meeting Rooms, Sanitary Facilities, Workshop, Laboratory, Water Museum, etc.;
- ✓ Electrical substation – it shall transform the 63kV network power into the respective voltage that shall feed the Transformation Stations;
- ✓ Water Tank and Pumping Station - with a capacity of 1800 $m^3$, this reservoir serves to store


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the water produced in about half an hour. The joint Pumping Station will serve to house the pumps that send the water to the DELIVERY POINTS.

This Project was based on the Hydraulic Process and Architecture Preliminary Study Project.

The following is a description of the conditions, with all options considered, solutions adopted and the methodology followed in the preparation of this Project.

## 6.2. Conditions

There are some structures at the new plant site that must be considered in the project, namely some houses and a workshop.

The workshop and neighboring residence shall be reallocated and demolished.

Gerôncio Brígido Neto street shall be partially used.

## 6.3. Preparatory Works

### 6.3.1. Demolitions

There are a few residences and a workshop currently located on one of the blocks pertaining to the area planned for desalination plant implementation, which will require demolition.

## 6.4. Platform Infrastructure

### 6.4.1. Landscaping

For landscape platform implementation at the Central plant area, the reference level of + 13.49 m was used.

Prior to the earth movement execution, the removal of vegetation with an average thickness of 0.20m shall be carried out.

Embankments shall consist of material prevenient from borrow sites, since the entire platform shall be over an embankment. 1:2 slopes (V/H) are recommended for embankments.

### 6.4.2. Drainage

The rainwater drainage network is intended to drain water from the plant's platform, internal roads and surrounding land.

The proposed drainage system layout is presented in the drafted pieces.

After an analysis of the data collected and proposed layout, a pre-sizing assessment was performed considering the size and shape of the contributing hydrographic basins, rainfall intensity, the respective time of concentration and return period.

The period of return adopted was 5 years for a rainfall of 5 minutes, with a precipitation intensity of 0.0367 L/s, considering Fortaleza’s the rainfall data.

Thus, the following bodies were considered to drain the generated flow:

- ✓ Reinforced concrete pipes;
- ✓ Inspection pits;
- ✓ Discharge nozzles;
- ✓ Water drop inlets;
- ✓ Water drops;



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- ✓ Energy dissipators;
- ✓ Drainage grid channels;
- ✓ Half pipe drains;
- ✓ Trapezoidal ditches for slope protection;
- ✓ Gutters and concrete flowlines on internal roads;
- ✓ Sub-horizontal drains;
- ✓ Slotted drain inlets;
- ✓ Grate inlets.

#### 6.4.3. Pavement

The interior streets shall have a total width of 7.0 meters with a single cross slope of 2%, with gutters and/or concrete flow lines on the sides.

The pavement of the internal roads and the access road shall have a hot-mix bituminous concrete finish.

For the Capture Chamber and Filters area a gravel coating will be provided.

#### 6.4.4. Landscaping Integration

Grass planted in slabs, trees planted in the entrance area and hydrosowing shall be provided in all other unpaved areas.

#### 6.4.5. Fencing

The plant's platform will be enclosed with a rigid Bekaert fence established over a 0.50 m high reinforced concrete base.

#### 6.4.6. Outdoor Lighting Network

The location, number of light points and light fixture types will obey the assigned architect's criteria, always respecting NBR 15129 of 07/2012. However, at this stage, the outdoor lighting network has already been identified (see project drawings). A set of light fixtures was distributed to illuminate essential spaces, street network, the substation and filter area. This was based on NBR 15129 of 07/2012. The distribution undertaken at this stage of the project may change according to new elements received.

The switchboard in the Administration Building will supply the Main Switchboard of the Final Product Storage Building and Pumping Station, which will have an installed electric power of approximately 1020 kVA. The installation of a responsible infrastructure is expected, allowing the interconnection of the buildings' switchboards. In addition, the Desalination Plant's outdoor lighting shall also be powered by the Electric Panel to be installed in the Administration Building.

The complex shall have inspection pits installed on the pavement, to facilitate the passage and installation of cables that shall feed electrical infrastructures.

### 6.5. Structures

#### 6.5.1. Introduction

The structures considered in this reference project are:

Intake Chamber and its respective building;

Foundation for para the Filtration Reservoirs – 1$^{st}$ e 2$^{nd}$ Stages;



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Process Building;

Administrative Building;

Electrical Substation structures;

Product Water Tank and Pumping Station.

This Structural Project was based on the architectural solution presented in the corresponding chapter. The following is a through description of the conditions, options undertaken, solutions adopted and methodology followed in the preparation of this Structural Project.

### 6.5.2. Structural Solution

The structural design aimed to obtain a resistant structure, as inexpensively as possible. It shall fulfill the proposed architectural prerequisites entirely, allowing a simple and efficient construction process, adapting itself to a reduced construction period and mandatorily meeting its structural function with total safety.

The structural foundations and the subsequent load transmission onto the ground is guaranteed through indirect foundations, of the site-molded piles type, with diameters of 100 cm or 120 cm.

#### 6.5.2.1. Intake Chamber

For the intake chamber, a structure made entirely of reinforced concrete with walls with thicknesses between 40 cm and 60 cm was designed. The deep slab is 80 cm thick.

For the protection of equipment and external tanks, a metal cover based on metal frames composed of HEA200 vertical elements and IPE300 beams was selected.

#### 6.5.2.2. Process Building

For the process building’s ground floor slab, the proposed solution consists of a 30-cm thick reinforced concrete floor slab. This slab unloads on a set of beams, which, in turn, carry the loads to the foundation blocks that lay over the piles.

For the building's facades and roof, a metallic structure was projected, consisting of several ASTM A572 GR50 medium steel profiles, through main portal frames, 7.5 m apart. The portal pillars shall be made of HEA300 type profiles and IPE400 trusses, locked by IPE200 or IPE240 profiles.

#### 6.5.2.3. Administrative Building and Brine Reservoir

For the Administrative Building, reinforced concrete beams and pillars were designed to support the floor slabs, also made of reinforced concrete, 18 or 20 cm thick.

The brine reservoir is rectangular geometry plan of 13.20 by 5.60 m, with an interior liquid height of 6.0 m. Walls entirely made of reinforced concrete, with thicknesses varying between 30 and 50 cm are suggested. A solid reinforced concrete slab was designed for the bottom slab, with an overall thickness of 35 cm and 50 cm under the peripheral wall bases.

A 20-cm reinforced concrete slab is projected to cover brine reservoir, which coincides with the slab on the 1st floor of the Administrative Building.

#### 6.5.2.4. Pumping Station and Product Water Tank

The product water reservoir has a rectangular shape and a plan of 26.00 m by 6.00 m, with an interior liquid height of 5.0 m. Walls fully built in reinforced concrete with thickness varying between 30-40



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cm are projected. A bottom slab of solid reinforced concrete was established, with an overall thickness of 30 cm and 50 cm underneath peripheral wall bases.

The pumping station structure consists of a 25-cm thick reinforced concrete ground floor slab, directly supporting a set of reinforced concrete gutters which, in turn, are supported by foundation beams with a 30 cm base and 80 cm high section, which transfer the loads to the foundation blocks at the pile heads.

The pumping station roof slab consists of 20-cm thick solid reinforced concrete, which supports a set of reinforced concrete beam frames and pillars.

For the slab covering the product water reservoir, a 25-cm reinforced concrete slab is projected, supported by the reservoir walls and 80-cm tall beams.

#### 6.5.2.5. Filter Support Structure

The first and second stage filters consist of 22 cylindrical reservoirs, 24 m long and 4 m in diameter, each weighing approximately 450 tons.

These reservoirs are elevated from the ground, being supported by reinforced concrete bases, fixed on piles. A pile cap block makes the connection between the pile and the base. Longitudinal beams will also be provided support the massifs, to resist eccentricity due to pile loading and positioning. These beams will also serve to standardize the settlements between the foundations of the same reservoir.

#### 6.5.2.6. Electrical Substation

For the plant’s electrical supply, a 69/13.8 kV Electrical substation with approximately 15.50m x 11.70m will be built inside the platform.

In civil construction terms, the works projected for this substation are:

- ✓ Equipment support foundations and structures;
- ✓ Power Transformer foundations;
- ✓ Foundations for the switchboard containers;
- ✓ Platform gravel coating;
- ✓ Peripheral Sealing.

This contract shall also provide the necessary infrastructure to route the underground electric supply wiring between the substation and the transformation posts inside the buildings.

### 6.5.3. Geotechnics, Foundations and Excavations

The Attachment 28814.8 presents a Geotechnical Report specific to the area.

Based on these elements, two types of foundations were considered for the plant structures:

- ✓ Indirect pile foundations - for the main structures, such as buildings, the Collection Chamber, reservoir and filtration tanks, pile foundations with 1000- or 1200-mm diameter and an approximate length of 30 m shall be considered;
- ✓ Direct foundations - for secondary structures and those less susceptible to different settlements, such as the Substation and lighter equipment foundations, direct foundations with contact voltages not exceeding 150 kPa were elected;
- ✓ Soil excavation - conventional mechanized excavation was projected.



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- ✓ Rock excavation – thermal spalling with mandatory use of pre-cracking, a process also known as sculptural spalling.

For the specific Collection Chamber case, a curtain of jet-grouted columns is expected (approximately 32 meters long each), which shall serve as a temporary containment from a structural point, as well as an important wall permeability reducer. This curtain will be sealed by steel struts during excavation, that shall guarantee safety and the construction of the final walls in reinforced concrete.

The execution of a pit bottom buffer with 4.0 m thick jet-grouting drying columns is also projected. Column diameter and spacing must be defined by the contractor, in order to guarantee bottom plug closure, and consequently, ensure tightness of the excavation pit bottom.

### 6.5.4. Materials

#### 6.5.4.1. Concrete

The structural concrete to be used for the elements must be the C40 (fck = 40 MPa) type, according to NBR 6118/2014, which classifies the environmental aggressiveness as a class IV – Very Strong – Marine Environment – Table 6.1.

The maximum water/cement ratio adopted is 0.40. Cement consumption should be at least 390 kg/m$^3$.

CP III-40 cement (with 70% blast furnace slag content) shall be used. Sulfate Resisting Cement or any other that compromises mixture resistance to chloride aggression shall not be used.

In the Collection Chamber, 10% silica fume shall be used over the mortar.

The lean concrete to be used shall have fck = 10 MPa resistance.

Covers to be elected for reinforced concrete shall be of at least 50 mm in slabs, beams and columns.

The structures in contact with seawater shall have a minimum coverage of 70 mm.

#### 6.5.4.2. Concrete Finishes and Protection

Although this document suggests structural waterproofing and protection material, it is essential that there is an executive waterproofing project.

Metal shapes and appropriate release agents should be used for all exposed concrete elements.

Elements in contact with soil:

- ✓ Two crossed coats of asphalt emulsion according to NBR 9685, with at least 3.0 (three) mm of dry film thickness

Elements in contact with water:

- ✓ Two crossed coats of epoxy paint coating (Icosit K 101 TW from Sika or equivalent) on an epoxy-based primer (SikaGard 720 EpoCem from Sika or equivalent)
- ✓ Permeability-Reducing Admixture for Hydrostatic conditions (PRAH) according to ACI 212.3
- ✓ All concrete joints should receive hydro-expanding profiles glued along the entire length

Outdoor exposed concrete elements:

- ✓ Painting with three coats of acrylic sealer, according to NBR 15.885 (Igolflex Fachada da Sika or equivalent)


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Interior floors:

- ✓ Finishing with mechanical trowel and floor hardener applied by sandblasting (SikaFloor 3 QuartzTop from Sika or equivalent) with epoxy paint (Sikafloor 390 from Sika or equivalent).

#### 6.5.4.3. Steel

The passive reinforcement steel will be of the CA-50 (fsyd = 435 MPa and fsyk = 500 MPa) and CA-60 (fsyd = 521 MPa and fsyk = 600 MPa) types, according to ABNT 7480/ 2007.

The following steel types shall be adopted for the metallic structure:

- ✓ ASTM A572 Grade 50 in profiles and plates (fy = 345 MPa and fu = 450 MPa);
- ✓ ASTM A500 Grade A in tube profiles (fy = 274 MPa and fu = 320 MPa);
- ✓ S350GD + Z275 (EN 10346) in purlins (fy = 350 MPa and fu = 420 MPa);
- ✓ ASTM A325 Type 1 (fy = 635 MPa and fu = 825 MPa) on screws;
- ✓ ASTM A193 Grade B7 (fy = 725 MPa and fu = 860 MPa) in anchors bolts.

#### 6.5.4.4. Steel Protection

For the metal profiles and passive armature steel to be employed in the Collection Chamber, the use of epoxy coating is projected as specified below.

Surface Preparation

- ✓ Abrasive blasting at SA 2 ½, according to ISO 8501-1;

Painting

- ✓ Application of a 100 µm epoxy zinc rich primer coat with glass beads (Hempadur AvantGard 750 or equivalent);
- ✓ Application of a 200 µm epoxy intermediate coat (MIO Hempadur 47300 or equivalent);
- ✓ Application of a 100 µm polyurethane finish coat (Hempathane 55930 or equivalent), in the final design color;

### 6.5.5. Calculation Actions

In the structural studies, the Permanent Loads corresponding to the weights of specific materials used were considered, as well as the loads resulting from use.

#### 6.5.5.1. Permanent Loads

| | | |
|---|---|---|
| ✓ Structural steel weight | 7.85 | $tf/m^3$ |
| ✓ Concrete weight | 2.50 | $tf/m^3$ |
| ✓ Glass weight | 2.50 | $tf/m^3$ |
| ✓ Floor covering | 0.10 | $tf/m^2$ |
| ✓ Covering | 0.25 | $tf/m^2$ |
| ✓ Covering (toilets and offices) | 0.25 | $tf/m^2$ |
| ✓ Coating (coverage) 0.25 tf / m² | | |

#### 6.5.5.2. Live Loads:

| | | |
|---|---|---|
| ✓ Load - Slabs (stairs) | 0.30 | $tf/m^2$ |
| ✓ Load - Slabs (offices and restrooms) | 0.20 | $tf/m^2$ |
| ✓ Load - Accessible terraces | 0.10 | $tf/m^2$ |
| ✓ Load - Non-accessible roofs | 0.05 | $tf/m^2$ |



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- ✓ Load - Slabs 0.50 tf/m²

#### 6.5.5.3. Retraction

Retraction was related to a uniform temperature variation of –20ºC in a simplified manner.

#### 6.5.5.4. Temperature Variation

To assess this indirect action over concrete elements, a uniform value of +/- 15ºC was considered, as indicated in NBR 6118. And since it is a slow action, the concrete's secant elastic modulus value was reduced in half.

#### 6.5.5.5. Wind

The wind actions were determined according to NBR 6123/1988, considering a basic speed of V0 = 30 m/s, a statistical factor of S3 = 1.00, a topographic factor of S1 = 1.0 and a terrain roughness category II for a Class C building.

#### 6.5.5.6. Overhead Crane Mobile Load

Overhead crane loads with the following capacities were considered:

- ✓ Collection Chamber - 5 tons;
- ✓ Process Building - 15 tons;
- ✓ Pumping Station - 5 tons;

### 6.5.6. Combination of Actions

The combinations of actions considered are those described in standards NBR 8800, NBR 6118 and NBR 8681, using those in which the base variable actions are overloads, uniform temperature, retraction and wind, with the following partial safety factors.

| | $\gamma_f$ | $\psi_0$ | $\psi_1$ | $\psi_2$ |
|---|---|---|---|---|
| Own weight | 1.40/ 1.00* | --- | --- | --- |
| Permanent | 1.40/ 1.00* | --- | --- | --- |
| Retraction | 1.40/ 0.00* | --- | --- | --- |
| SC Flooring and stairs | 1.40/ 0.00* | 0.6 | 0.4 | 0.3 |
| SC Roof | 1.40/ 0.00* | 0.0 | 0.0 | 0.0 |
| Temperature | 1.20 /0.00* | 0.6 | 0.5 | 0.3 |
| Wind | 1.40 /0.00* | 0.6 | 0.3 | 0.0 |

*If the action is favorable

Last Combinations of Actions

- ✓ Combination 1= $\gamma_{gi}$ · Permanent actions + $\gamma_q$ · [Main variable action + $\Psi_0$ · Other variable actions]

Combination of Service Actions

Quasi-permanent

- ✓ Combination 2 = Permanent actions + $\Psi_2$ · Variable actions

Frequent



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- ✓ Combination 3 = Permanent actions + $\Psi_1$ · Main variable action + $\Psi_2$ · Other variable actions

Uncommon

- ✓ Combination 4 = Permanent actions + Main variable action + $\Psi_1$ · Other variable actions

### 6.5.7. Calculation Methodology

To obtain the calculation models that defined the structural behavior of this building, the SAP2000 automatic finite element calculation program was elected.

The program uses the finite element method to discretize the structure, and the static calculation is performed by solving the following system of linear equations:

$$Ku = R$$

Where:

- ✓ K – stiffness matrix
- ✓ u – displacement vector
- ✓ R – load vector

The dynamic analysis is obtained through the following system of dynamic equilibrium equations, which relates soil movement to the structural response:

$$M\acute{u} + C\acute{u} + Ku = M\acute{u}_g$$

Where:

- ✓ M – mass matrix
- ✓ K – stiffness matrix
- ✓ $\acute{u}_g$ – ground acceleration
- ✓ C – damping matrix
- ✓ u ´, u ´eu - acceleration, speed and displacement of the structure

This program solves the equation systems using the mode overlapping method for an approximate response spectrum.

The ground acceleration curve is introduced through a Table that relates the spectral acceleration with the respective period.

Ground excitation can occur in three directions: two in the horizontal plane, perpendicular to each other, and the third in the vertical plane.

The determination of maximum effort and displacements is done by calculating the modal responses associated with the main excitation directions and total response, corresponding to the sum of the responses associated with the three directions, by quadratic combination.

### 6.5.8. Safety Verification and Sizing

Verification of the structure's security, in relation to the Last Limit States and Usage Limit States, was carried out based on the efforts determined through the structural analysis previously described and based on the regulations in force that are specified in the next chapter.

### 6.5.9. Regulations and standards

For the elaboration of this Project, the following regulations and standards were used:



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- ✓ [1] NBR 6118-2014: Concrete Structure Design - Procedure.
- ✓ [2] NBR 12655-2015: Portland Cement Concrete - Preparation, Control and Receipt - Procedure.
- ✓ [3] ABNT NBR 8681-2003: Structure Actions and Safety - Procedure
- ✓ [4] ABNT NBR 8800-2008: Steel Structure and Mixed Steel and Concrete Structure Design for Buildings.
- ✓ [5] ABNT NBR 6120-1980: Loads for structure calculations
- ✓ [6] ABNT NBR 6122-2010: Foundation designs and executions
- ✓ [7] ABNT NBR 6123-1988: Wind loads on buildings

## 6.6. Water Networks

### 6.6.1. Water Supply Network

The cold potable water network originates from the Public Infrastructure Network. It is understood that the public network has the necessary flow and diameter conditions to supply these facilities.

Only one pressurizing plant was projected to guarantee the pressure necessary to supply all water consumption devices.

A totalizing water meter shall be installed downstream of the public network branch valve, next to the building's facade.

Ball valves shall be installed for diameters up to 2”; butterfly valves shall be installed for larger diameters.

A connection between the water distribution building and the sanitary sewer building networks will not be allowed.

Water supply to the sanitary parts will be carried out without jeopardizing their potability, preventing their contamination, either by contact or aspiration of residual water in case of depression.

The basic elements related to building water distribution were the part types projected for use, their minimum flow rates and respective pressures (according to ABNT NBR standards).

To obtain the water supply network’s sizing, the load units or relative weights method was used. Relative weights are established empirically in function the project’s design. The amount of each type of working parts supplied by the pipes included in the calculation is multiplied by the corresponding relative weights; then, the sum of the values obtained in the multiplications by all part types constitutes the total sum of the weights (ΣP).

Using the equation presented below, this sum is converted into the total simultaneous demand of parts group, which is expressed as a flow estimate to be used in pipe sizing. This method is valid for facilities intended for normal use of water and equipped with sanitary appliances and usual working parts.

$$Q = 0.30 \times (\Sigma P)^{1/2}$$

Where:

- ✓ **Q** is the estimated flow in the considered section, in liters per second;
- ✓ **ΣP** is the sum of relative weights of all working parts supplied by the respective pipe.



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The diameters are determined based on the flow rate, flow velocity and pressure drop in the pipes. The diameters to be used are those indicated in the drafts.

Flow velocity in the pipes were obtained based on the flow rates and pipe diameters, and have a maximum value of v < 3.0 m/s.

Under dynamic conditions (with flow), water pressure at the points of use must be established to guarantee the projected flow specified by law and proper operation of the working part and the sanitary apparatus.

In any case, the pressure must not be less than 10 kPa, with exception of the discharge valve site towards the sanitary basin, where pressure must not be less than 15 kPa.

Under static conditions (without flow), water pressure at any usage point of the building's distribution network should not exceed 400 kPa.

The occurrence of overpressure due to water hammer must be considered in pipe dimensioning. Such pressures are permitted, provided they do not exceed 200 kPa.

Head loss throughout a pipe depends on its length and internal diameter, internal surface roughness and flow. Pressure drop in tube connections, composing the piping, must be expressed in terms of tube equivalent lengths.

A real pipe length percentage has been estimated as the equivalent length needed to cover head losses in all connections. This percentage may vary from 10% to 40% of the actual length, depending on pipe design complexity.

The pipes to be considered will be the following:

- ✓ Brown rigid PVC with welding tip and pouch, for distribution lines embedded in masonry or exposed, with diameters up to 110 mm;
- ✓ Rigid PVC with elastic joints, class 20, PBA-type, in the buried network.

The pipes shall be installed on a mat over the ceiling, exposed, embedded in the masonry or buried. Pipe minimum diameter, including sub-branches, will be 25mm.

The distance between pipe supports must respect manufacturer recommendations. Individual water meter valves shall be installed in every branch and connection and kept in a visible, accessible and easy to identify location, allowing tube isolation, even of those that are small, for maintenance and repair operations.

According to the law, buried pipes must be at least 50 cm under their bedding, and 30 cm deep in other occasions.

#### 6.6.1.1. Network Accessory Elements

**Piping**

Brown rigid PVC, with welding tip and pouch and diameters up to 110 mm.

Rigid PVC with elastic joints, class 20, PBA type, in the buried network.

Reference: Tigre, Amanco or equivalent.

**Valves and Meters**


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The ball and butterfly valves shall be installed in the sites established in the project, and shall shut off water flow for facility maintenance.

Water meters up to 4” must be in bronze, threaded, with a non-rising stem.

Water meters above 4” must be made in flanged bronze.

Reference: DECA, FABRIMAR, DOCOL.

**Equipment**

Before installing any equipment, the manufacturer must be consulted in order to provide all necessary equipment manuals, to allow the responsible professional to install all automation equipment correctly.

### 6.6.2. Domestic Sewage Collection Network

All sanitary sewage shall be collected in the sanitary devices through the discharge branches. The discharge branches shall deliver their effluents to collectors, and later to a manhole.

All sanitary sewer networks shall run by gravity to the public sewage collection network around the plant area, presuming there is a quota for this network.

In case it does not exist, it will be necessary to install a pumping well with submersible pumps at the lot entrance, to route sewers to the public network according to the requirements of NBR 8160/99.

Sanitary sewer drainage will consist of:

- ✓ Extension connections for various devices;
- ✓ Manholes and buried collectors;
- ✓ Ventilation network gathered in groups under the roof, in order to minimize holes in the roof.

The piping will be installed in a manner that allows for desilting or repairs to take place whenever necessary.

There should be no diagonal or oblique piping, except in the discharge branches of the sanitary pieces, as long as there are no inconveniences.

According to NBR 8160, the open end of a primary ventilation pipe or ventilation column must not be located less than 4.00 m from any window, door or ventilation gap, unless it is raised at least 1.00 m above the lintels of the respective spans. It must also be located at a minimum height of 2.00 m above the roof, when located in technical areas. Above the roof, ventilation columns must be made of cast iron or galvanized steel and must have ventilation terminals.

All tubes will have the sections that indicated in the drawings, or those recommended by regulations.

The surface or visit pipes will be classified according to the nature of the transported waters, according to the established standard rules.

No connection between the buildings’ water distribution network and the sewage collection network shall be allowed.

The sanitary sewage collection and disposal system is completely independent of the rainwater system, with no possibility of connection between them.

#### 6.6.2.1. Sizing



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The collection networks were dimensioned according to NBR 9649, "Execution of Public Wastewater Systems" and NBR 8160/83.

The Hunter Contribution Units (HCU) method was used for the sanitary sewage network sizing.

An HCU is the numerical probabilistic factor that represents the frequency of use associated with the typical flow rate for the different parts of set of different devices operating simultaneously, at the time of maximum contribution (Plínio, T.).

According to NBR 8160/83, the minimum nominal diameters of the discharge branches must be respected.

For dimensioning and corresponding hydraulic checks, the Manning Formula was used:

Where:

- ✓ Q - flow, in $m^3/s$;
- ✓ A - wet perimeter area, in $m^2$;
- ✓ R - wet perimeter hydraulic radius, in m;
- ✓ i - collector slope, in m / m;
- ✓ n - roughness coefficient (PVC n = 0.010);

The minimum nominal diameter of the discharge branches will be 50mm.

The minimum nominal diameter of the pipe used in the collectors will be 100mm.

#### 6.6.2.2. Materials

The pipes to be considered, in the apparent and buried network, will be the following:

- ✓ Rigid PVC reinforced pipe for collectors, drop tubes and the buried network;
- ✓ Normal Rigid PVC for the discharge branches and the ventilation network.

The pipes will be embedded in the masonry or buried.

#### 6.6.2.3. Syphons / disconnectors

Disconnectors are devices provided with a water seal, designed to stop the passage of gases in the opposite direction to the sewage displacement. All sanitary appliances must be served individually or collectively, by disconnectors. Brazilian standard NBR 8160 recommends a 5cm minimum height for disconnector water seals.

#### 6.6.2.4. Regulations

For the performance of this study and in all other cases, all current technical standards will be respected, including *ABNT* - Brazilian Association of Technical Standards:

- ✓ Regulations and Guidelines from the Water and Sanitation Company of Cuiabá-MT (SANECAB);
- ✓ NBR 8160 - Building Sanitary Sewage Systems - Design and Execution;
- ✓ BR NBR 9649 - Sewage collection network designs;
- ✓ NBR 5688 - Building rainwater, sanitary, sewage and ventilation systems - PVC pipes and connections, DN type - Requirements.

### 6.6.3. Rainwater Collection Network


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The rainwater network drainage shall be carried out through the traditional system and includes drainage of rainwater from the roof.

Rainwater drainage shall consist of:

- ✓ Hanging gutters along the roof;
- ✓ Pending projected in the roof;
- ✓ Rain gutters along the roof;
- ✓ Dome drains and drop tubes;
- ✓ Overflow pipes to be provided for roof gutters and around the drains, with the dimensions indicated on the planks;
- ✓ Buried manholes and collectors.

Rainwater from the roof will be transported by gravity to the outdoor drainage network.

The pipes that are apparent or subject to visitation shall be identified according to the nature of the water they transport, according to the established standards.

A connection between the building's water distribution and the rainwater collection networks will not be allowed.

The rainwater collection and destination systems are totally independent from the sanitary sewer system, with no possibility of connection between them.

#### 6.6.3.1. Sizing

To determine the project discharge to be used in the hydraulic design of drainage devices, the Rational Method was used, through the expression.

$$Q = C.i.A$$

Where:

- ✓ Q is the project peak discharge ($m^3/s$);
- ✓ C is the runoff coefficient;
- ✓ i is the rainfall intensity considered ($m^3/s.ha$);
- ✓ A is the drainage area (ha).

The following values were adopted based on waterproofing of the drained surface:

Coverage: 1.00.

When calculating rainfall intensity, a return period (T) of 10 years and a rainfall duration (t) of 5 minutes will be considered.

The rainwater drainage system runoff devices were designed based on the Manning-Strickler formula, associated with the continuity equation, through the expression:

$$Q = \frac{1}{n} \cdot Rh^{2/3} \cdot i^{1/2} \cdot S$$

Where:

- ✓ Q is the flow rate ($m^3/s$);
- ✓ n is the roughness coefficient of the conduit;
- ✓ Rh is the hydraulic radius (m),



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- ✓ i is the duct longitudinal slope (m / m);
- ✓ S is the wet perimeter (m2).

#### 6.6.3.2. Material

The piping to be considered will be the following:

Rigid PVC reinforced sewer pipe, in the discharge branches of devices and collectors and dropshaft pipes;

The connections must correspond to the piping characteristics.

#### 6.6.3.3. Standards

For the performance of this study and in any event, all current technical standards will be respected, including *ABNT* - Brazilian Association of Technical Standards:

- ✓ Regulation and Guidelines of the Basic Sanitation Company of the State of São Paulo (SABESP);
- ✓ NBR 10844 – Rainwater building installations;
- ✓ NBR 15527 – Rainwater – Use of roofs in urban areas for non-potable purposes - Requirements;
- ✓ NBR 5688 – Building rainwater, sanitary sewage and ventilation systems. PVC pipes and connections, DN type - Requirements;
- ✓ NBR 8890 – Circular concrete tube for rainwater and sanitary sewage - Requirements and test methods.

## 6.7. HVAC Installations

### 6.7.1. Introduction

The Heating, Ventilation and Air Conditioning (HVAC) project will focus only on the Process Building, Administrative Building, Reservoir and Pumping Station.

A description of the conditions, considered options, solutions and methodology followed to prepare this project in accordance with the applicable rules is presented below.

### 6.7.2. Objective

In a general manner, the HVAC Installations proposed and developed for the building must ensure:

A. Cooling needs
B. Treated fresh air (heat treatment)
C. Mechanical exhaust ventilation
D. Natural Ventilation
E. No defined HVAC system

The spaces corresponding to each objective are displayed in the following table:

Table 6.7 – HVAC Requirements by Area

| Area | HVAC Needs | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| **Process Building** | | | | | |
| Production Room | | | | ✓ | ✓ |



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| Area | HVAC Needs | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| **Reservoir Building and Pumping Station** | | | | | |
| Pump Room | | | | ✓ | ✓ |
| Electrical Room | ✓ | | | | |
| Maneuver Chamber | | | | | ✓ |
| Reservoir | | | | | ✓ |
| **Administrative Building** | | | | | |
| Warehouse/File room | | | | ✓ | ✓ |
| Workshop | ✓ | | ✓ | | |
| Electrical Workshop | ✓ | | ✓ | | |
| Electrical Room | ✓ | | | | |
| Laboratory | ✓ | | ✓ | | |
| Kitchen | ✓ | | ✓ | | |
| Sanitary Installations/Dressing Room/Restroom | | | ✓ | | |
| Entrance | ✓ | | | | |
| Hallway | | | | | ✓ |
| Office/Control room/Observation Room | ✓ | ✓ | ✓ | | |
| Meeting Room | ✓ | ✓ | ✓ | | |
| Museum | ✓ | ✓ | ✓ | | |
| Auditorium | ✓ | ✓ | ✓ | | |

Note: For the ESP steels in which air-conditioning is projected, (A) the set point temperature is 24°C. For the ESP steels with mechanical ventilation (B e C), indoor air refreshing shall be in accordance with their characteristics.

The project's systems and equipment allow the building's thermal needs to be met throughout the year, in accordance with the climatic conditions of the geographical area corresponding to Fortaleza, Brazil.

## 6.7.3. Reference Conditions and Sizing Criteria

### 6.7.3.1. Standards and Regulations

**Brazilian Standards:**

- ✓ ANVISA – Agência Nacional de Vigilância Sanitária (Sanitary Surveillance National Agency).
- ✓ NBR 16401-1 / 2 / 3-2008 – Air-conditioned Facilities - Central and Unit Systems – Facility Design / Thermal Comfort Parameters / Indoor Air Quality.
- ✓ ANVISA - National Health Surveillance Agency

**International Standards**

- ✓ Portuguese Decree DL 118/2013 and respective addendums, the latter expressed in DL


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28/2016, referring to the Building Energy Certification System (SCE), the Housing Building Energy Performance Regulation (REH) and the Energy Performance Regulation for Commerce and Service Buildings (RECS).

- ✓ ASHRAE – "American Society of Heating, Refrigeration and Air Conditioning Engineers";
- ✓ All other applicable legislation and rules.

### 6.7.3.2. Weather Data

The weather data considered were based on the information provided by the 2017 ASHRAE report for the weather station in Fortaleza (Airport), with 99.6% occurrence probability.

- ✓ Exterior Temperature – Summer
  - Dry bulb temperature 32.1°C
  - Wet bulb temperature 24.9°C
- ✓ Exterior Temperature - Winter
  - Dry bulb temperature 22.8°C

### 6.7.3.3. Indoor Temperature Conditions

For the assessment and calculation of temperature needs for air-conditioned spaces, the following temperatures shall be considered:

- ✓ Air-conditioned spaces (type A): 24 °C
- ✓ Other spaces: -- °C

There is no effective control of indoor humidity; however, the systems considered, when condensing air in indoor air conditioning units, must provide relative humidity within the comfort zone.

Due to the warm temperatures that occur all year round, heating needs are not predicted.

### 6.7.3.4. Internal Gains

To determine heat gain, local indications (NBR) and international references (ASHRAE) were consulted, as well as typical values for the different types of spaces that make up this building.

The following table shows the proportions considered for each area with any degree of heat treatment.

Table 6.8 - Occupation, Lighting and Equipment

| Area | # Occupants | Lighting [W/m²] | Equipment [W/m²] |
|---|---|---|---|
| Warehouse/File Room | -- | -- | -- |
| Workshop | 16 | 17 | 75 |
| Electrical Workshop | 5 | 17 | 75 |
| Electrical Room | -- | -- | 150 |
| Laboratory | 6 | 15 | 75 |
| Kitchen | 5 | 7.6 | 50 |
| Sanitary installations/Dressing room/Restroom | -- | -- | -- |
| Entrance | 2 | 11.4 | 0 |
| Hallway | -- | -- | -- |
| Office | 2 | 12 | 35 |
| Control room | 4 | 12 | 35 |



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| Area | # Occupants | Lighting [W/m²] | Equipment [W/m²] |
|---|---|---|---|
| Observation Room | 15 | 11.4 | 35 |
| Meeting Room | 19 | 12 | 10 |
| Museum | 72 | 7.2 | 5 |
| Auditorium | 185 | 12 | 5 |

#### 6.7.3.5. Fresh Air Flow / Extraction

The minimum fresh air flow considered was the following:

Table 6.9 – Fresh Air Flow / Extraction by Area

| Area | Fresh Air Flow | | |
|---|---|---|---|
| | $m^3/h/p$ | $m^3/h/m^2$ | By unit |
| Warehouse/File Room | -- | -- | |
| Workshop | 18 | 3.24 | |
| Electrical Workshop | 18 | 3.24 | |
| Electrical Room | -- | -- | |
| Laboratory | 22.68 | 3.96 | |
| Kitchen | -- | 5.4 | |
| Sanitary Installations/Spa | -- | -- | 126 |
| Dressing Room | -- | 16 | |
| Entrance | -- | -- | |
| Hallway | -- | -- | |
| Office | 11.16 | 1.44 | |
| Control Room | 11.16 | 1.44 | |
| Observation Room | 11.16 | 1.44 | |
| Meeting Room | 11.16 | 1.44 | |
| Museum | 19.08 | 1.44 | |
| Auditorium | 12.6 | 1.44 | |

### 6.7.4. Adopted solutions

#### 6.7.4.1. Air-conditioning system

In spaces with type-A air conditioning, different suggestions are provided depending on the type of use. In the offices, meeting room, workshops, laboratory, pantry, observation room and entrance, a VRF (Variable Refrigerant Flow) system will be installed, where an outdoor condensing unit interconnects several indoor wall units, or cassette units.

This type of system allows a more efficient room temperature control throughout the year compared to a split system or multi-split option, through a variable refrigerant gas flow, which adjusts to the needs of each space. The indoor units must be connected to a condensate drainage network.



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For the control room, as it is assumed that it should have permanent occupation, a multi-split system will be installed, with an outdoor unit on the roof and two indoor units. The switchboard room will also be cooled using a multi-split.

The switchboard room in the pump building will also be air-conditioned using multi-split units.

The auditorium and the museum, which, despite being on different floors, will be interconnected through an open area. It was decided to place a large split system with an outdoor unit with a serpentine and fan, and a separate condensing unit.

The explanation for the use of an air-conditioning suggestion different from the others in these two spaces is related to their intermittent use, which makes it easier to adapt the cooling power provided to their respective needs.

The cooling requirements (sensitive power), determined for the various air-conditioned rooms (type A) are summarized below:

Table 6.10 – Cooling Power by Area

| Area | Cooling Power (kW) |
|---|---|
| **Reservoir Building and Pumping Station** | |
| Electrical Room | 9.3 |
| **Administrative Building** | |
| Workshop | 8.6 |
| Electrical Workshop | 2.9 |
| Electrical Room | 21.3 |
| Laboratory | 5.7 |
| Kitchen | 1.9 |
| Entrance | 1.1 |
| Office | 0.8 |
| Control Room | 9.6 |
| Observation Room | 3.9 |
| Meeting Room | 5.2 |
| Museum | 8.6 |
| Auditorium | 19.9 |

The copper and condensate piping must be properly insulated to reduce thermal losses, as well as to prevent condensation.

The HVAC systems sensors/controllers must be placed in a way to avoid being affected by extraordinary thermal sources, or direct solar radiation.

The outdoor unit must be installed with anti-vibration supports.

#### 6.7.4.2. Ventilation Systems

The Process Building, as well as the pump room in the Reservoir Building and Pumping Station shall be naturally ventilated. This option is due to the buildings' exposure to sea winds, which in this



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location are quite significant in terms of magnitude and occurrence, greatly reducing installation and usage costs.

Natural ventilation consists in air flowing from outside to keep the temperature at acceptable values for work inside the building. For this end, grids will be installed on the building facades according to the prevailing winds, in this case, coming from the east and southeast. In the two facades most exposed to the prevailing winds, grids will be installed throughout the building at a low level. In the two opposite façades, high-level air expulsion grids shall be created. In the Pumping Building there shall be an extraction grid on the facade opposite to the air inlet, which shall be located according to the prevailing wind as well.

The changing rooms and restrooms shall have a mechanical extract ventilation system done by a fan. In the same way, air extraction in the kitchen and laboratory will be done independently. It shall be done by fans located on the roof of the Administrative Building.

The workshops on the ground floor of the Administrative Building, shall have the same mechanical extract ventilation system, with the air extracted through the roof. These spaces shall have a fresh air supply.

The remaining spaces identified in the Table above will be equipped with extraction fans and fresh air.

The air extracted from the sanitary facilities, pantry and laboratory will be compensated in the hallways.

For the auditorium and museum, the chosen split allows the introduction of new air-conditioning, with extraction done by fan.

The flow balance is carried out to guarantee a good air circulation inside the building, avoiding the propagation of odors.

Ducts and diffusers must be painted according to the surroundings and architecture.

#### 6.7.4.3. Electrical Installations Associated to HVAC

The supply from switchboards that supply HVAC equipment will be ensured by the Electrical Installations specialty.

The power cables and electrical connections to the HVAC equipment will be ensured by the Electrical Installations specialty.

Command and control cables, field equipment and the respective connections to HVAC equipment will be provided by the HVAC specialty.

It is the Mechanical Installations contractor’s responsibility to provide the Electrical Installations contractor in advance with all the electrical characteristics of such equipment and certify that the aforementioned electrical supplies, protections and signage are in accordance with the specifications of the equipment to be installed, always as described in the HVAC project.



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## 6.7.5. Duct Network – Sizing, Criteria and Accessories

### 6.7.5.1. Sizing

This project exclusively contemplates systems of constant air volume in which the air flows are driven by fans of the centrifugal type, or of the axial type.

Pipeline sizing shall be calculated considering the flow to be circulated, location and the noise generated.

In this manner, the pipeline network was dimensioned for a constant pressure drop that might be of 0.8 Pa/m (insufflation) or 1.0 Pa/m (extraction).

### 6.7.5.2. Projected Pipeline Types

Several types of pipelines have been defined for different uses, which are indicated below:

- ✓ Galvanized sheet steel ducts: for all general extraction networks and general fresh air
- ✓ Insulated galvanized steel ducts: for all air-conditioned, fresh air networks

## 6.7.6. Pipeline Network– Sizing and Criteria

### 6.7.6.1. Refrigerant Gas Lines

Line gauge is dimensioned considering the equipment manufacturer's recommendations and indications. The maximum distances between the condensing unit and the evaporating unit must also respect each application and manufacturer's instructions.

The lines must be properly insulated and, in indicated cases, mechanically protected.

## 6.7.7. Noise Levels

The equivalent continuous noise level emitted to the outside of the building by equipment must not exceed the maximum permissible levels. The equipment associated with emergency situations are an exception. For this purpose, and so that the HVAC system is not the source of vibration or noise above the defined comfortable limits, the installation of the following accessories shall be considered, whenever justified:

- ✓ Anti-vibration mounts for all equipment, including indoor units, fans, etc.
- ✓ Installation of inertia blocks in all equipment, where necessary.

# 6.8. General Electric Network

## 6.8.1. Administrative Building

### 6.8.1.1. Power feed and distribution

All electrical panels must have double insulation (class II) or equivalent protection. From the electrical panels, the following circuits shall be established:

- ✓ Normal and Safety Lighting;
- ✓ Power outlets;
- ✓ Specific feeds;
- ✓ Switchboard feeds.

A 45kVA load balancing is projected for the Administrative Building, to supply equipment related to the lighting and outlet subspecialties.


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The switchgear and protection equipment to be used in switchboards must strictly comply with the applicable regulatory provisions (see NBR 5410/2004).

The Administrative Building must be equipped with full power cut pushbuttons, controlling the Main Switchboard, next to this building's inlets and outlets (see drawing).

#### 6.8.1.2. Cabling Pathways, Technical Gutters and Floor Boxes

In this phase of the project, mats are designed, with representative dimensions, to provide infrastructures that will allow cable passage and placement. These mats shall be adequate to the project's characteristics. Cable trays with metal plate and normal resistance will be implemented.

The technical wall gutters shall be made of PVC, with dual compartments, intended to separate the energy and telecommunications conduits, including angles, covers and all accessories necessary for their correct installation. The installation of floor boxes will be expected; however, in later stages of the project, these elements may change.

#### 6.8.1.3. Normal Lighting

Respecting the standard related to indoor lighting, NBR ISO/CIE 8995-1, the distribution, number of light spots and fitting types are described in the section designed for normal lighting. In addition, it is intended to obtain a proper environment for each space, according to its functionality. Current technical and regulatory provisions will also be considered.

Lighting for all spaces will be performed with LED light fittings. In all locations, the fittings shall respect the mandatory protection index, according to the site classification.

Control of the fixtures in the Administrative Building will be local; however, in the changing rooms and sanitary facilities, motion detectors will be used.

#### 6.8.1.4. Safety and Emergency Lighting

The installation of exit signs comprises the exit signal devices and their corresponding supply circuits, and is intended to guarantee, automatically, the indication of exits and the identification direction changes and obstacles in the evacuation path, allowing evacuation of people.

For safety lighting, permanent and non-permanent devices shall be used as an autonomous block, depending on the areas in which they shall be inserted. The autonomous block locations are displayed in the respective draft.

Safety lighting shall consist of autonomous blocks, equipped with LED lamps and internal batteries. In addition, the same draft will display the light fixtures, equipped with an emergency kit, to help comply with the rules regarding safety lighting (NBR 10898 of 03/2013).

#### 6.8.1.5. General Purpose Power Outlets and Specific Supplies

To allow the connection of electric power devices to be installed in different building locations, the power outlets must comply with NBR 14136/02. Single-phase power outlets for general use of small voltages must be watertight and surface mounted, embedded in the wall, set in the cable tray and floor box. Single-phase high-voltage sockets and three-phase sockets shall be watertight and surface mounted.

The supply to specific equipment, through cable end boxes, shall have the equipment installation as a height reference.



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#### 6.8.1.6. Grounding System

Steel pickets shall be installed as reinforcement to the grounding system, with electrolytic copper plating over a layer of nickel.

All non-visitation connections shall be CADWELD aluminum welded.

The building shall have its own ground ring, installed at a depth of 0.8m and consisting of a 30 x 3.5 mm flat conductor in stainless steel, with high resistance to corrosion, suitable for the plant's environment.

To obtain a correct equipotential bonding between the grounding system and the structure, the iron reinforcement connections shall be made through a claw connector for ribbed steel bars. Connections to the metallic structures will be made by split bolt for stainless steel structures.

#### 6.8.1.7. Telecommunication Installations

The network to be installed adopts a star topology. The installation must comply with current Brazilian standards in NBR 1652, of 10/2016.

The rack in FLOOR 0 of the Administration Building with area of influence on the same floor shall be considered as the telecommunications point of origin.

The building shall be equipped with surface-mounted, embedded RJ45 sockets, placed in a cable tray and floor box.

#### 6.8.1.8. Security installations

The present integrated security chapter include the following subspecialties: Automatic Fire Detection System (*SADI*) and Automatic Intrusion and Theft Detection System (*SADIR*).

In addition to what is provided in current standards, this facility must have security means to allow the acquisition of an interconnected equipment set, that, while easy to monitor and control, displays the necessary operational and quality levels.

#### 6.8.1.9. Automatic Fire Detection System – SADI

This project defines the location of the equipment that composes the Automatic Fire Detection System. The equipment's quality level and assembly requirements, location adjustments and complementary work from other specialties shall be defined in the later phases of the project.

It is projected to cover all areas indicated in the drafts designed with an Automatic Fire Detection System, with quality and reliability levels appropriate to the predicted operating conditions.

#### 6.8.1.10. Automatic Intrusion and Theft Detection System – SADIR

It is projected to cover all areas indicated in the drafts designed with an Automatic Intrusion and Theft Detection System, with quality and reliability levels appropriate to the predicted operating conditions.

However, the equipment's quality level and assembly requirements, location adjustments and complementary work from remaining specialties shall be defined in the later phases of the project.

This system shall allow centralization of all security facility commands and signals, or those related to them, especially with regard to the automatic start of different procedures.

### 6.8.2. Process Building

#### 6.8.2.1. Power Feed and Distribution



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All switchboards must have double insulation (class II) or equivalent protection. From the switchboards, the following circuits shall be established:

- ✓ Normal and Safety Lighting;
- ✓ Power outlets;
- ✓ Switchboard feeds.

The Process Building is projected to have a load balancing of 37kVA, to supply equipment related to lighting and outlets subspecialties.

The switchgear and protection equipment to be used in the switchboards will strictly comply with the applicable regulatory provisions (see NBR 5410/2004).

The Process Building must be equipped with full power cut pushbuttons, controlling the FLOOR 0.1 Switchboard, next to the building's switchboards.

#### 6.8.2.2. Cabling Pathways

In this phase of the project, cable mats with representative dimensions are projected to provide infrastructures that will allow cable passage and placement. These mats shall be adequate to the project's characteristics. The cabling pathways shall be installed with a metal plate and normal resistance.

#### 6.8.2.3. Normal Lighting

Respecting the standard related to indoor lighting, NBR ISO/CIE 8995-1, the distribution, number of light spots and fitting types are described in the section designed for normal lighting. In addition, it is intended to obtain a proper environment for each space, according to its functionality. Current technical and regulatory provisions will also be considered.

Lighting for all spaces will be performed with LED light fittings. In all locations, the fittings shall respect the mandatory protection index, according to the site classification.

The Process Building's lighting fixture controls shall be located in the switchboards.

#### 6.8.2.4. Safety Lighting

The installation of exit signs comprises the exit signal devices and their corresponding feed circuits, and is intended to guarantee, automatically, signage to the exits and identification of direction changes and obstacles in the evacuation path, allowing evacuation of people.

For safety lighting, permanent and non-permanent devices shall be used as autonomous blocks, with or without maintenance, depending on the areas in which they shall be inserted. The autonomous block locations are displayed in the respective draft.

Safety lighting shall consist of autonomous blocks, equipped with LED lamps and internal batteries. The safety lighting shall comply with the safety lighting rules (NBR 10898 of 03/2013).

#### 6.8.2.5. General Purpose Power Outlets

To allow connection of electric power devices that shall be installed in the different locations in the building, the power outlets must comply with NBR 14136/02. Power outlets for general single-phase and three-phase uses must be watertight and surface mounted.

#### 6.8.2.6. Grounding system


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To obtain a correct equipotential bonding between the grounding system and the structure, the iron reinforcement connections shall be made through a claw connector for ribbed steel rods. Connections to the metallic structures will be made by split bolt for stainless steel structures.

Steel pickets shall be installed as reinforcement to the grounding system, with an electrolytic copper plating over a layer of nickel.

All non-visitation connections shall be CADWELD aluminum welded.

### 6.8.3. Pumping station

The Pumping Station building will be fed from the Administrative Building and shall have the following networks, following the same criteria:

- ✓ Electric power feed and distribution
  - Normal and Safety Lighting
  - Electrical outlets
  - Switchboard feed
- ✓ Cable trays
- ✓ Regular lighting
- ✓ Safety lighting
- ✓ General purpose outlets
- ✓ Grounding system

### 6.8.4. Collection chamber

The Collection Chamber building will have its own PT and will be fed directly from the Electrical Substation. The following networks will be harbored in it, complying with the same criteria defined for the remaining buildings:

- ✓ Electric power feed and distribution
  - Normal and Safety Lighting
  - Electrical outlets
  - Switchboard feed
- ✓ Cable trays
- ✓ Regular lighting
- ✓ Safety lighting
- ✓ General purpose outlets
- ✓ Grounding system

## 6.9. Seawater Intake and Discharge Works

### 6.9.1. Seawater Intake Tower

The projected structure will be prefabricated onshore in separate pieces, composing a reinforced concrete structure designed to protect the submarine seawater intake area.

The structure shall be built in separate pieces because its full weight is excessive. It is estimated that the complete set structure is close to 215 tons. Nearly 250 $m^2$ of molds and 8500 kilos of steel rods shall be used for its construction.

Before the structure's base is anchored on the seabed, at an approximate height of -14.0 m and distance of 2500 m from the coast, an excavation for its support foundation shall be executed in the


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sand, through a dredging system that shall open the ditch to install submarine intake piping. This final excavation shall result in a circular shape identical to the predicted structural base, which shall have an approximate 7.50 m diameter. The reinforced concrete structure shall be about 5.75 meters tall.

The submarine tower will basically consist of a hollow cylindrical shape placed over a circular-shaped protective structure. In the cylinder's upper area, eight small windows with a combined dimension over 8 $m^2$ will be left for the passage of quality water and small fish, which can easily enter and exit the box, while preventing grains of sand and algae from entering. Thus, it actually allows collected water to be as clear as possible in terms of ocean properties.

The prefabricated parts will be placed on the seabed, starting with the lower and ending with the upper parts, with use of suitable marine means. Installation and assembling operations for the parts shall be guided and completed by a team of professional divers, certified and qualified to perform heavy work in the deep sea.

Near the tower cylinder's foundation, a pipe bushing with a diameter identical to the seawater intake's end pipe shall be installed. The connection between the intake piping and tower shall be executed through flanges.

The connecting pipe shall also have a small metal screen at its terminal end to prevent medium-size fish or debris from entering the Desalination Plant system.

To obtain a pre-sizing, small calculations were made to find tipping for static forces, considering an apparent submerged density of 1.5 for concrete calculation, caused by forces originated by large waves.

A calculation was also executed for lateral drag forces. Due to the small friction coefficient considered, attained through the Chezy number for depths around 15 meters and in sand material, the solution found for stabilization was to provide the supplementary rock blocks placed together, in a circular shape over the bottom structural slab, with an additional weight of about 100 tons of material.

Proper signage will be placed at the seawater surface to prevent ships large in size and draft from crossing over to the site, possibly dragging or damaging the structure.

### 6.9.2. Intake and Discharge Pipes

- ✓ IP – intake pipes for seawater intake: 3141 m in length, 1600 mm diameter, 94.1 mm thickness, HDPE material and 306 Kgf / ml linear weight.
- ✓ DP – brine discharge pipes: 1752 m long, 1200 mm diameter, 67.9 mm thickness, HDPE material and 207 Kgf / ml linear weight.

### 6.9.3. Intake Transport Execution / CA:

Preliminary note: the natural terrain from which the intake well shall spring is located outside the plant's Process Building, and has an approximate +13.49 m level in relation to the MSL (mean sea level). Head losses were estimated according to the following benchmarks:

- ✓ Flow velocity: 1.63 m/s;
- ✓ Seawater intake flow rate: 9170 $m^3$/h or 2.55 $m^3$/s;
- ✓ Total head losses: 3.39 m;
- ✓ *BMAV* Mean (Low Water in Living Tides): -1.60m MSL;
- ✓ *PMAV* Mean (Low Water in Living Tides): + 2.80m MSL;
- ✓ Piezometric head at the onshore chamber entrance in *BMAV*: -1.60-3.39 = -4.99 m MSL;


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- ✓ Piezometric head at the onshore chamber entrance in *PMAV*: + 2.80, -3.39 = -0.59 m MSL;

### 6.9.4. Discharge Piping Installation / DP:

**Phase 1 -** The reject water discharge process, which is also called “brine discharge” in a simplified manner, that results in water with a salt concentration about twice as high than that of seawater through the Plant’s reverse osmosis process, shall extend through approximately 532 meters. It will start with an inland section, with 1200 mm diameter tubes welded at the top and brine distribution diffusers in its final 25 meters of marine extension, continuing for an average of 1220 meters.

Its calculation parameters were decided according to the following reference values:

- ✓ Flow velocity: 2.02 m/s;
- ✓ Seawater discharge flow rate: 6470 $m^3$/h or 1.80 $m^3$/s;
- ✓ Continuous linear head loss: 4.26 m;
- ✓ Pressure drop in the diffusers: 1.10 m;
- ✓ Total head loss: 5.36 m;
- ✓ *BMAV* Mean (Low Water in Living Tides): -1,60 m MSL;
- ✓ *PMAV* Mean (High Water in Living Tides): + 2.80 m MSL;
- ✓ Piezometric head in the brine tank during *BMAV*: -1.60 + 4.26 = + 2.66 m MSL (situation in which the pipeline works by gravity going upstream and under pressure in the terminal end);
- ✓ Piezometric head at the onshore chamber entrance in *PMAV*: + 2.80 + 4.26 = + 7.06m MSL (situation that indicates that the brine tank height should be greater than indicated).

A twice as high salt concentration at the product outlet does not pose environmental problems, and would only start to generate some ecological concern in a coefficient above 3.5, and even then, at a single concentrate outlet site, the which is not the case.

In the section where the pipeline ends at the seabed, the outfall will have to be complemented by 1,200 mm diameter tubes welded with ring counterweight structures fixed to its posterior side, in order to make the set density higher than the water’s.


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# 7. Electrical Installation

## 7.1. General Electric Characteristics

### 7.1.1. Power Feed and Distribution

All electrical panels must have double insulation (class II) or equivalent protection. From the electrical panels, the following circuits shall be established:

- ✓ Safety lighting and Lighting;
- ✓ Power sockets;
- ✓ Specific feeds;
- ✓ Switchboard feeds.

The switchgear and protection equipment to be used in the switchboards must comply with the applicable regulatory provisions (see NBR 5410:2004).

The Administrative Building shall be equipped with full circuit breaker pushbuttons, which shall act on the Main Switchboard.

### 7.1.2. Cable Layout

According to the project, conduits and cable troughs should be installed, to allow cable passage and layout.

Electrical troughs with regular resistance metal plates shall be installed.

The wall wiring troughs will be PVC-made, with dual compartments, intended for the separation of the energy and telecommunications conduits, and must include all the accessories necessary for its correct installation.

### 7.1.3. Indoor Lighting

The indoor lighting must comply with NBR ISO/CIE 8995-1, and be executed with LED light fixtures. In all locations, the fixtures shall respect the mandatory protection index, according to the site's classification.

Light fixture control in the Administrative Building will be local; however, in the changing rooms and sanitary facilities, motion detectors must be used.

### 7.1.4. Safety and Emergency Lighting

The installation of safety signs is intended to guarantee, automatically, the exit signals and the identification of changes in direction and obstacles in the escape routes, allowing evacuation.

For safety lighting, permanent and non-permanent autonomous block devices shall be used, depending on the areas in which they must be installed.

The autonomous blocks must be equipped with LED lamps and internal batteries. In addition, the location of the fixtures equipped with an emergency kits shall be displayed on the same draft, in compliance with emergency lighting rules (NBR 10898 of 03/2013).

### 7.1.5. General Purpose Power Outlets and Specific Supplies



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General purpose power outlets must comply with NBR 14136/02. Low power outlets must be built into a wall or electrical trough. High-power outlets should be of an industrial type.

The electrical feed to specific equipment shall have the equipment installation as a reference of height.

### 7.1.6. Grounding

The grounding meshes must be assembled using of 50 $mm^2$ bare copper cables, buried at least 50 cm deep, with 3/8" by 3.00 m ground rods and exothermic welding;

All metal parts, electrical panels and metal parts inside the building (doors, hoists / monorails), general low voltage switchboard (LVSB), light and power distribution board (LDB), Motor Control Center (MCC), capacitor and motor bank boards shall be embedded into the general grounding mesh.

The maximum allowable grounding resistance for the meshes to be built should be 10 ohms.

Grounding resistance measurements must be carried out before the meshes are interconnected.

The depth for the grounding mesh cables and interconnection loops must be at least 50 cm.

If the maximum value of 10 ohms is not reached for each grounding mesh, it must be expanded, or betonite can be applied throughout the rods and cables.

### 7.1.7. Telecommunication Installations

A star network system shall be adopted. The installation must comply with existing Brazilian standards, NBR 16521 of 10/2016.

The network rack that exists on Floor 0 of the Administration Building, influencing this same floor, will be considered the original point of the telecommunication installations.

The building will be equipped with overlapping RJ45 sockets or embedded in a wiring trough or wall.

### 7.1.8. Security installations

The integrated security installations include the following subspecialties: Automatic Fire Detection System (*SADI*) and Automatic Intrusion and Theft Detection System (*SADIR*).

The security system should allow the acquisition of an interconnected equipment set, that, while easy to monitor and control, displays the necessary operational and quality levels.

### 7.1.9. Automatic Fire Detection System – *SADI*

The necessary coverage for the Automatic Fire Detection System should be provided, with adequate levels of quality and reliability.

### 7.1.10. Automatic Intrusion and Theft Detection System – *SADIR*

The necessary coverage for the Automatic Intrusion and Theft Detection System should be provided, with adequate levels of quality and reliability.

## 7.2. Codes and Standards

The electrical installation complies with the following codes and standards:

- ✓ Brazilian ABNT standards.
- ✓ International Electrotechnical Commission (IEC).
- ✓ Institute of Electrical and Electronic Engineers (IEEE).



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In all cases, the most restrictive code or standard prevailed. In particular, the following rules apply:

- ✓ IEC 60051 – Electrical measurement instruments with direct acting analog indication and their accessories.
- ✓ IEC 60076 – Power transformers.
- ✓ IEC 60034 – Rotating electrical machines.
- ✓ IEC 60269 – Low-voltage fuses.
- ✓ IEC 60289 – Transformers. Reactances.
- ✓ IEC 62271-200 – Apparatus with alternating current metallic enclosures for nominal voltages above 1 kV and less than or equal to 52 kV.
- ✓ IEC 60529 – Degrees of protection provided by enclosures (IP Code).
- ✓ IEC 60146 – Semiconductor converters.
- ✓ IEC 60439 – Low voltage switchgear.
- ✓ IEC 60947 – Low voltage connection and control device.
- ✓ IEC 61000 – Electromagnetic compatibility (EMC).
- ✓ IEC 62040 – Uninterruptible power supply (UPS).
- ✓ IEC 60694 – Common determinations in high voltage device standards.
- ✓ IEC 60099 – Lightning arresters
- ✓ IEC 60071 – Insulation coordination.
- ✓ NBR 5410 – Low voltage electrical installations.
- ✓ NBR 14039 – Medium voltage electrical installations from 1.0 kV to 36.2 kV.
- ✓ IEEE 1184 Guide for the selection and sizing of batteries for uninterruptible power system.
- ✓ IEEE 450 Recommended practice of maintenance, testing and replacement of vented lead-acid batteries for stationary applications.
- ✓ IEEE 519 Guide for harmonic control and reactive compensation of static power converters.

## 7.3. Project Criteria

The electrical system shall be projected to meet the following criteria:

- ✓ Flexibility and progress of the operation.
  - The project must provide for 100% redundancy of the equipment that, in the event of failure, will cause the factory to stop.
  - The protection relays will be coordinated for selective activation of the different switches. The overload or short circuit situations shall be isolated without service interruption and without affecting the rest of the equipment connected to the same system.
- ✓ The project shall facilitate inspection, maintenance and repair works in the facilities.
- ✓ Safety:
  - Includes adapting the energy system used during plant construction as a backup energy system that guarantees electricity supply to essential equipment in emergency conditions.
  - The safety of people and equipment must be guaranteed, including the necessary electrical and/or mechanical interlocks.
  - Disturbances during the initial phases of different equipment use shall be minimal.
- ✓ Economy and efficiency in the installation project:
  - The selected equipment sets and components should be standardized to cover a wide range of applications and reduce inventory.
  - The selection of equipment and material must prioritize heat loss reduction, reduced



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energy consumption and low $CO_2$ emission.

## 7.4. Voltage Levels

The following voltage levels were established to supply the plant's electromechanical equipment:

- ✓ The connection to the electrical system is made at 69 kV high voltage.
- ✓ Power distribution to the desalination plant shall be carried out at 6.6 kV, 60 Hz and three phases, from the plant's 69/6.6kV Electrical Substation.
- ✓ Medium voltage motors:
  - They shall be supplied with a 6.6 kV, 3P + PE voltage, with low ohmic value resistance grounding.
- ✓ Low voltage motors:
  - Motors and process equipment shall be powered at 380/220 V, 3P + PE or 3P + N + PE (as applicable), with TT neutral system (IEC 60364).
  - Small power and lighting distribution shall be performed at 380/220 V, 3P + N + PE, with TT neutral system (IEC 60364).
- ✓ Safe alternating current (AC) power system:
  - UPS equipment shall be powered at 380 Vac, 3P + N + PE, with neutral TT system (IEC 60364).
  - The Distributed Control System (DCS), local panels with Programmable Logic Controllers (PLC) and process instruments require it to be powered at 230 V from the UPS.
- ✓ Safe direct current (DC) power system:
  - The supply for the relays, control circuits and medium voltage cell signage are made at 127 Vdc through a charger/rectifier, with a TT neutral system (IEC 60364).
  - The 24 Vdc or 48 Vdc power supply for the control and instrumentation panels shall be performed from the 127 Vdc system.

## 7.5. Environmental conditions

The environmental conditions considered are as follows:

| | |
|---|---|
| Height above mean sea level | <100 m |
| Relative humidity (annual average) | 75% |
| Average daily room temperature | 30 ºC |
| Project minimum temperature for equipment installed indoors in system containing rooms | 40 ºC |
| Project minimum temperature | - 5 ºC |
| Type of environment | Saline |

## 7.6. Equipment Protection Levels

The protection levels defined for the equipment, as referenced in the IEC 529 standard, are as follows:

| | |
|---|---|
| Equipment installed inside air-conditioned rooms | Min. IP41 |
| Control cabinets installed in air-conditioned rooms | Min. IP32 |



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| | |
|---|---|
| Equipment installed indoors in rooms without air conditioning | IP55 |
| Equipment installed outdoors, in shaded areas | Min. IP65 |
| Dry-type transformers | IP23 |
| DC and UPS Systems | IP32 |
| Equipment subject to occasional submersion (submerged pumps, etc.) | IP68 |
| Light fixtures and projectors | IP65 |
| Perforated cable trays in buildings | IP25 |
| Outdoor flat cable trays with cover | IP33 |

## 7.7. Reserve and Redundancy Margins

The project displays the following reserve and redundancy margins:

- ✓ 6.6 kV underground transmission line. Each of the substation's medium voltage connections is projected to 100% of the total power demanded by the plant.
- ✓ Medium voltage cabins can be powered by two different sources and are equipped with automatic transfer systems. In general, loads shall be distributed in two bars fastened by a coupling switch, so that in the event of failure, the plant’s service continuity is at least 50%. A more robust and secure system than a double bus can be designed.
- ✓ The MCCs and low voltage load distribution boards can be powered from two different sources.
- ✓ Transformers and redundant transformers: they must have sufficient capacity to withstand100% of the load of the coupled bars. That is, in the event of any transformer failure, there would not be a prolonged shutdown in the plant, as the transformer that remains operational will have sufficient capacity to supply the entire load for the two bars.
- ✓ Medium voltage cells: They are projected to withstand 10% over than the maximum short-circuit current predicted according to the calculations (1 second).
- ✓ High current busbars: they are dimensioned with a margin of 10% over the transformer’s nominal current.
- ✓ Input switches and bus coupling of switchboards powered by a transformer. They are dimensioned with a 10% margin over the transformer’s nominal current.
- ✓ 100% redundancy of the safety-related electrical equipment is available: DC system and UPS.
- ✓ Batteries. A project margin of 15% and aging factor of 25% are expected. The capacity of each battery guarantees 100% charge for 1 hour.
- ✓ Battery charger. It is projected with a 10% margin over the maximum peak power demand.
- ✓ UPS. It is dimensioned with a 20% margin over the maximum peak power required.
- ✓ Cable trays. They shall be sized maintaining a 20% reserve on all routes.
- ✓ Switchboards, MCCs and local plates. They shall be dimensioned considering a 20% reserve without equipping after the expansion phase.

## 7.8. Facility Description

### 7.8.1. Electrical substation 69/6.6 kV



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The power source shall be provided through a 69-kV high voltage overhead line. The installation of a 69/6.6 kV transformer substation is projected to supply the 6.6 kV medium voltage power source for the desalination plant. The substation will be conventional, with a single busbar and two transformer positions, with a total 15 MVA capacity.

### 7.8.2. Electrical Supply to the Desalination Plant

The desalination plant shall be powered by the new 69/6.6kV Electrical Substation.

The supply for the different transformation centers (T2 and T3) shall be carried out by underground medium voltage lines of 6.6 kV 60 Hz, from the 69/6.6 kV substation.

Each of the projected lines is dimensioned to supply all the power demanded, that is, 2 lines x 100% capacity. The medium voltage lines start from the connection terminals with the Switchgear 6.6kV output cells (bars A and B), located in the Electrical Substation and extending until the transformation center connection terminals.

The medium voltage cable outside the buildings is laid out in direct-burial, in contact with the earth. Inside the buildings, the medium voltage cable is placed in the cable tray.

The cable to be used will be a 6/10 kV, IEC 228 class 2 copper conductor, unipolar with cross-linked polyethylene insulation, reinforced (with galvanized steel wires) and PVC sheathed, according to IEC 60502-2.

The cable screens shall be solidly grounded at each end.

### 7.8.3. Power Distribution

The plant's electrical equipment shall be installed in different buildings, placing them as close as possible to the most important loads. According to this approach, three electrical rooms are projected:

#### 7.8.3.1. Main Electrical Room

It shall be located in the Substation building. The following items will be installed in it:

- ✓ 6.6kV Switchgear. It shall be composed by:
  - Cells that supply T2A and T2B, 6.6/0.4 kV, 60 Hz and 3500 kVA medium voltage transformers, for low voltage distribution in osmosis and chemical cleaning areas.
  - Medium voltage cells that serve high-pressure pump motors (1800kW) and capacitor banks for these motors’ reactive power compensation (345kVar).
  - Protection cells for medium voltage inverters that service seawater intake pump motors.
- ✓ T2A and T2B, 6.6/0.4 kV, 60 Hz and 3500 kVA Transformers. The two transformers shall be installed next to the electrical room, in independent facilities adapted to the equipment’s respective characteristics.
- ✓ The Product Water Motor Control Center.
- ✓ The Chemical Cleaning Pumps Motor Control Center.
- ✓ Medium voltage frequency inverters, soft starters, capacitor banks, UPS, rectifiers and batteries.

#### 7.8.3.2. Electrical Room at the Osmosis Building

A second room located in the osmosis building is projected. In this room, the following will be installed:

- ✓ Transformers T3A and T3B, 6.6/0.4 kV, 60 Hz, 3500kVA, to supply the recirculation and


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booster pumps feeding the high-pressure pump, both driven by low-voltage frequency variators. The two transformers shall be installed next to the electrical room, in independent facilities adapted to the characteristics of this equipment.

- ✓ CBT-SA1, main distribution switchboard for auxiliary, common and essential services in the osmosis area.
- ✓ A 380V low voltage motor control center for MM filter cleaning operations.
- ✓ A 380V low voltage motor control center for recirculation and booster pumps.
- ✓ A 380V low voltage motor control center for chemical dosing systems.
- ✓ Variable frequency drives, soft starters, capacitor banks, UPS, rectifier devices and batteries for the pretreatment area.

#### 7.8.3.3. Intake Electrical Room

In this third room, the following will be installed:

- ✓ TBT-SA2, a low-voltage load distribution board for the common and essential services derived from the pre-treatment building.
- ✓ A 380V low-voltage motor control center for chemical pre-treatment dosing.

The motor control centers and switchboards can be powered by two different sources. The loads are divided into two bars connected by coupling switches. Service distribution between bars is carried out through a homogeneous criterion for load distribution, so that, as far as possible, duplicate services are fed from different transformers to increase facility reliability. The transformers were designed to temporarily absorb loads from the two bars. The transformers do not work in parallel.

### 7.8.4. Medium voltage cells

A set of medium voltage cells was designed, with the following configuration:

| DESCRIPTION | UNITS |
|---|---|
| HIGH-PRESSURE PUMP CONDENSING CELL | 2 |
| HIGH PRESSURE PUMP CELL | 2 |
| SEAWATER PUMP VDF CELL | 3 |
| TRANSFORMER CELL 3A | 1 |
| TRANSFORMER CELL 2A | 1 |
| INSTALLATION CELL T1A | 1 |
| COUPLING CELL | 1 |
| INSTALLATION CELL T1B | 1 |
| TRANSFORMER CELL 2B | 1 |
| TRANSFORMER CELL 3B | 1 |
| SEAWATER PUMP VFD CELL | 2 |
| HIGH PRESSURE PUMP CELL | 2 |
| HIGH-PRESSURE PUMP CONDENSING CELL | 2 |



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The 7.2 kV medium voltage cells (6.6 kV operating voltage) are designed according to the IEC-62271-200 standard, classification LSC2B-PM-IAC-AFLR, with air insulation (AIS) and SF6 circuit breakers. The enclosures will be metallic, of the modular, self-supported type, for internal and continuous assembly.

The cabins are single bar sets formed by couplings, with a grounding bar. The bars will be made of high conductivity copper. All metal structures, covers, screens and barriers shall be directly connected to the grounding bar.

Each set of cells shall withstand all thermal and dynamic stress caused by the short-circuit currents without damage. A symmetrical 25 kA short-circuit current capacity was estimated.

Entrance to the cable cabinets shall be made from the bottom.

The cabinets are equipped with removable keys, SF6 vacuum cut and motorized control. The measurement and protection transformers are cast-resin, dry-type.

Voltage, current, power and energy measurements at the cell set entries and the transmission of electrical parameters to the SDC shall be provided.

Each cell has a modular multifunctional digital protection relay, suitable for the cell's service (transformer, motor or power source), with communication capability and access from the central control system via RS485 communication port for Modbus protocol.

The cells' control circuits are powered by 230 Vac and/or 127 Vdc from the safe voltage system with redundancy in the power source. They shall allow local and remote switches for shutdown, blocking, status and alarm devices.

To prevent condensation inside each cell, a set of heating resistances, controlled by a thermostat, shall be provided. Lighting shall be incorporated into the accessible maintenance compartments.

The cabinets shall be equipped with the necessary interlocks to prevent false maneuvers.

The front part of each cabinet will have a synoptic display switch, local or remote, switching elements for disconnectors and switches, stop status signage, operation counter and voltage presence detector.

### 7.8.5. Transformers

As indicated in the previous sections, the following transformers shall be installed:

- ✓ T1-A and T1-B: 69/6.6kV, 60Hz, 15MVA, located at Electrical Substation for medium-voltage supply to the desalination plant.
- ✓ T2-A and T2-B: 6.6/0.4kV, 3500kVA, located in the Substation electrical room to provide low-voltage supply for the plant's Process Services and auxiliary substation.
- ✓ T3-A and T3-B: 6.6/0.4kV, 3500kVA, located in the Reverse Osmosis building to supply low-voltage power to the MCC.

The 69 / 6.6kV, 15MW high-voltage transformers shall be the oil type, class F, with projected temperature of 50ºC, ONAN / ONAF cooling and YNn0, for installation in outdoor facilities.

The 69 / 6.6kV transformer will have a load voltage regulator, with 21 outlets or loads (± 15%) located in the primary winding. It must be equipped with high-voltage bushings, valves to collect oil samples, filling and draining valves, protection and control block to detect liquid dielectric gas emissions,


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devices to detect excessive pressure increase in the tank, read liquid dielectric temperature and visualize the liquid level.

The 6.6/0.4 V, 3500 kVA low-voltage transformers shall be the dry type, class F, with projected temperature of 40 ºC, AN cooling and Dyn11 for indoor installation. The rigid neutral earthing is connected to the TT earthing. All transformers will be suitable for full, continuous load service in the environment, as defined in section 8.5, Environmental Conditions.

The MT/BT transformers shall have a manual vacuum voltage regulator, with five taps (± 2.5%; 0; ± 5%) located in the primary winding, winding temperature reading, two-contact bulb thermometer and thermostat.

In the case of transformers that supply non-linear loads, T3A and 3TB, disqualification factor K appropriate to the type of load was applied. These transformers incorporate electrostatic screens.

In addition to the above, all transformers must have an identification tag, grounding terminals, lifting hooks, supports for hydraulic jacks and transport wheels that can be removed and rotated in two directions.

The transformers shall have a system of mechanical/electrical interlocks that do not allow: connection of the voltage grid directly to the earth, supply to the facility in case of a short-circuit or ground failure, access to active parts, supply to secondary transformers from another source, causing dangerous stress in the transformer primary, supply to the same transformer in a closed circuit (transformers in parallel operation).

The maintenance compartment lock of each transformer will be mechanically interlocked with the grounding switch of the corresponding transformer protection cell. In this way, the transformer cannot be accessed without a previous shutdown of the protective cell’s grounding switch.

The transformers shall be installed in an independent compartment with dimensions sufficient to respect the minimum safety distances. The doors will open to the outside, allowing equipment to enter and exit. The transformers’ location shall facilitate direct access for loading/unloading trucks and/or cranes, limiting movement on its own wheels.

The facilities shall maintain adequate conditions of fire protection, restricted access, redundant air-conditioning system and dust protection.

### 7.8.6. Medium-voltage motors

The medium-voltage motors are those corresponding to:

- ✓ High-pressure pumps
- ✓ Seawater intake pumps

They shall be squirrel-cage, three-phase power motors, 6.6 kV, 60 Hz, class F and have a 40ºC projected temperature. They will be sealed with fan cooling, with IP55 protection level and finishes suitable for a saline environment. The service factor considered is 1.15.

The motor’s nominal voltage, in all cases, shall be of at least 110% of the maximum power required by the associated machine.



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A direct start drive is projected for high-pressure pumps motor operation, with an initial current limitation of 5xIn. The seawater intake pumps shall start with frequency inverters.

The motors shall have thermal resistances to prevent condensation. All motors incorporate Pt-100 temperature and vibration sensors, with two detectors on each winding and one per bearing.

All motors can be operated from their location, in the cabins and the control room.

### 7.8.7. Low-voltage motors

They shall be squirrel-cage, three-phase power motors, 400 V, 60 Hz, class F and have a 40ºC projected temperature. They will be sealed with fan cooling, with IP55 protection level and finishes suitable for a saline environment. The service factor considered is 1.15 and 1.0 in the case there is a frequency inverter. The motor design is in compliance with IEC 60034.

The motor's nominal voltage shall be of at least 110% of the maximum power required by the associated machine. For motors with a frequency inverter, the maximum torque supplied by the motor must be at least 40% greater than the load torque at any frequency, and the maximum permitted motor velocity must not be exceeded.

In motors with power equal to or greater than 50 kW, two PT100 temperature sensors shall be installed in each winding, and one per bearing.

The most important low-voltage motors can be operated from their location sites, cabins and control room.

### 7.8.8. Low Voltage Distribution Switchboards

The Low Voltage Distribution Switchboards will be located in the various electrical rooms. Its function is to protect and distribute power in an optimized and safe way to the different consumption points.

The following tables were designed:

- ✓ Load distribution switchboards for common and essential plant services:
    - TBT-SA1 Common and essential services in the Osmosis Building.
    - TBT-SA2 Common and essential services in the Intake Building.

The cabinets consist of standardized modular units of closed metal construction. The board shall have front access. The inlet is larger when the connection is made through a high voltage bar, but smaller if made through cables. The busbar for these cabinets shall be composed of an insulated copper plate and earth bar. At a minimum, they are projected to withstand 40 kA short-circuit currents.

The switchgear shall be removable for 400 A and higher, and fixed for smaller gauges.

The power input to the switchboard shall be equipped with a motor-controlled thermal-magnetic circuit breaker, a network analyzer, multifunctional protection relay and power factor relay (when applicable). The meters and relays shall have an RS485 communication port to comply with Profibus protocol.

The board outputs are equipped with an automatic circuit breaker and differential protection. Essential service bars have a power input from the generator set. They are equipped with an automatic thermal-magnetic circuit breaker and electrical/mechanical interlocks that prevent erroneous operation in emergency mode.


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### 7.8.9. Motor Control Centers

A total of 6 Motor Control Centers (MCCs) are located in the different electrical rooms. They are as follows:

- ✓ MCC 01, 380V, 60Hz, for chemical dosing before pretreatment.
- ✓ MCC 02, 380V, 60Hz, for MM filter washing.
- ✓ MCC 03, 380V, 60Hz, for recirculation and booster pumps
- ✓ MCC 04, 380V, 60Hz, for product water pumping.
- ✓ MCC 05, 380V, 60Hz, for chemical cleaning.
- ✓ MCC 06, 380V, 60Hz, for chemical dosing.

The MCCs must comply with the IEC 60439-1 standard, with a removable unit, 3b and 4b construction form for connections and IP54 protection level. They shall have front access and lower cable input/output, except in cases where MCCs are supplied directly by a transformer secondary, where the connection shall be made by a prefabricated electrical conduit.

MCCs will be equipped with a horizontal and vertical distribution copper bar compartment, as well as a grounding bar. The current short-circuit level for the offices will be adequate in each case, as the minimum will be 50 kA. They will have column heating elements and a cooling system in the inverter outputs' housing and soft starters.

The input modules shall have a thermal-magnetic switch, motorized control, interlocking when in open position, auxiliary contacts and electronic overload and short-circuit protection relay, signage lamps and rotary pushbutton on the door.

They will be equipped with current transformers for measurement and a voltage transformer for control circuits and combined type 1 and 2, 100 KA lightning rods.

A network analyzer is planned for all MCC entries, with an RS485 communication port for Profibus protocol, which allows the measurement and transmission of electrical parameters to the control center. Connections to the MCC at the same level will incorporate an automatic switching relay.

The measurement, control and control circuits shall have a thermal-magnetic switch.

The modules for bus couplings shall have automatic circuit breaker, motorized control, interlock in the open position, auxiliary contacts and electronic protection relay.

The initial modules will incorporate an automatic circuit breaker (in a molded case up to 630 A and in an open board for larger meters), with a valve interlock in the open position and rotary pushbutton on the door, three-pole contactor, thermal relay, differential relay, auxiliary relays, valve interlock on the open position, command position selector: local, remote and test; and signage lamps.

The types of start expected are as follows:

- ✓ Direct Start: until 5,5 kW.
- ✓ Soft-Starters: they will be installed on motors with a nominal voltage greater than 5.5 kW that do not work through a frequency inverter.
- ✓ Frequency inverters: they shall be installed on motors for whose process they are required.

The output modules for power supplies shall have a molded case thermal-magnetic switch with a rotary button on the door, auxiliary relays and signage lamps.



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### 7.8.10. Medium-voltage frequency inverters

The medium voltage frequency inverters for seawater intake pump operation, with 6.6 kV, 60Hz and 24 pulses, shall operate in two quadrants with pulse width modulation (PWM) and vector control.

Each frequency inverter will be mounted on a self-supporting independent panel with an integrated transformer. They shall have an air-conditioning system. The set will have at least an IP 42 degree of protection.

The frequency inverter must not reduce motor effective power (power reduction), require insulation improvement nor an additional service factor to that demanded by the load. It shall include filters that protect the motor against possible damage and voltage spikes in the output wave.

The medium voltage VDF minimum efficiency shall be 96% (including the transformer) at 100% speed and load. The frequency converter power factor will be 0.97 between 30% and 100% of the nominal voltage, and will be designed for 99.9% availability.

The frequency inverter set must comply with the established electromagnetic compatibility (EMC) requirements (IEC 61800-3) and total harmonic distortion (TDH) values at the coupling point (PCC) IEC 61800-3-12, IEEE 519.

### 7.8.11. Low-voltage frequency inverters

The low-voltage frequency inverters shall be in accordance with IEC 60146. They shall have 6-pulse rectifiers, low harmonic distortion, two-quadrant drives, pulse width modulation (PWM) and vector control, as well as input inductance for harmonic reduction and dv/dt output filters. VDF topology can be CSI (current source inverter), or, preferably, VSI (voltage source inverter), but IGBTs must be used in the rectifier and inverter modules.

Frequency inverters for motors with power equal to or greater than 50 kW will be bypassed and mounted on independent, self-supporting boards with front access.

The protection level will be IP 42.

The following pumps motors shall be powered by frequency inverters:

- ✓ Recirculation pumps, 380V
- ✓ Booster pumps, 380V
- ✓ Seawater intake pumps, 690V
- ✓ Chemical cleaning and displacement pumps, 380V
- ✓ Product water pump type nº1 and nº2, 380V

The frequency inverter set must comply with the established electromagnetic compatibility (EMC) requirements (IEC 61800-3), as well as with the total harmonic distortion (TDH) values at the coupling point (PCC) IEC 61800-3-12, IEEE 519.

### 7.8.12. Soft-Start Drive

Motors with power greater than 5.5 kW that are not driven by a frequency inverter will have electronic starters.

The soft-starters will have a bypass and be mounted on independent, self-supporting switchboards, with frontal access. The protection level will be IP 54.



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### 7.8.13. Power Factor Correction

To guarantee a power factor equal to or greater than 0.95 at the customer connection point (CCP) and improve the overall facility power factor, a reactive power compensation is proposed at several levels:

- ✓ Reactive power compensation produced by high-pressure pump medium-voltage motors. Individual compensation is provided in parallel to the machine, with a protection element and specific maneuver to avoid the capacitor bank self-excitation phenomena.
- ✓ Fixed value compensation associated with secondary transformers.
- ✓ A distributed compensation system was chosen individually, by panel, for low-voltage power factor compensation. Automatic self-regulating banks will be installed to correct the power factor caused by the different devices installed in low circuits. MCCs and TBT-SA will be connected to the common and essential services network.

The equipment's capacity is detailed in the calculation document. This equipment shall allow the facility to work at full capacity, with a power factor of 0.98.

The batteries will be protected by an automatic circuit breaker, insertion resistors and tuned filter reactors. The automatic condenser batteries shall also have an electronic regulator with a fieldbus communication port and be integrated into the plant’s control and general supervision system.

### 7.8.14. Cables

The medium voltage cable to be used will be the 6/10 kV, class 2 copper conductor IEC 228, with cross-linked polyethylene (XLPE) insulation for maximum service temperature of 90ºC and short-circuit at 250ºC and PVC layered, according to IEC 60502-2.

The low-voltage power cable to be used will be the 0.6/1 kV twisted copper conductor, with PVC insulation for permanent service maximum temperature of 90 ° C and short circuit at 250 ° C, PVC layered.

Cable cross-section calculated based on:

- ✓ The maximum permissible voltage for cables in permanent service. Voltage correction factors by temperature, type of load, coupling and type of assembly were considered.
- ✓ The maximum voltage drop, according to NBR 5410:
  - 5%, in relation to the delivery point.
  - 10% maximum at motor startup.
  - 4% maximum in terminal circuits (lighting and power)

The minimum established sections are as follows:

| | |
|---|---|
| ✓ Voltage | 4 mm2 |
| ✓ Commands and signage | 1,5 mm2 |

The neutral and protective earthing conductor sections must be dimensioned in accordance with applicable regulations.

The conductors that supply inverter motors shall be concentric and shielded. The cable screens will be grounded.

### 7.8.15. Prefabricated electrical ducts (busbar ducts)



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For 6.6/0.4 kV power transformers, the connection between the secondary transformer and the low-voltage switchboard is projected with use of a prefabricated electrical conduit. The prefabricated electrical piping will be designed according to the IEC 60439-2 standard.

The high voltage bars shall be made of copper or aluminum, in a steel shell. They will be fixed on ceilings and walls. All bar stages shall be sealed between different areas with flame retardant elements.

### 7.8.16. Local Pushbuttons

The main machines driven by electric motors shall be provided, in their vicinity, with a local panel and mushroom type button for an emergency machine stop, complying with IP – 65 protection index.

In the case of valve drives or motorized gates, the panels will have an opening push button, a closing button and an arrow type emergency stop button.

### 7.8.17. Direct current system

The DC system shall supply 127 Vdc power for the control and command of medium voltage circuit breakers.

Since many direct current systems are installed, there are two transformation centers in the plant: one in the Intake Building and the other in the Process Building.

The direct current system will be redundant, consisting of two chargers and two battery sets for 100% of the expected charge, with a 1-hour interval and a distribution board with dual power input. Batteries must be Ni-Cd, sealed and maintenance-free, with suitable non-corrosive or flammable enclosures that must be housed. The set is designed for indoor service.

The electric loaders and distribution cabinets shall be of self-supporting metal type, floor mounted, with IP54 protection level. The cabinets shall be accessible from the front, and cable entry points shall be located from the bottom of the respective front access, with fixed maneuvers.

### 7.8.18. Uninterruptible Power Supply (UPS)

An uninterruptible power system (UPS) is designed for each of the projected electrical rooms. The equipment's output voltage will be 220 Vac, 60 Hz, and will supply the DCS and I&C equipment and the rest of the plant's vital loads. The system shall be 100% redundant and consist of the following elements:

- ✓ 2x Pulse Width Modulated (PWM) Inverters
- ✓ 2x static bypasses, by dry transformer and stabilizer that will be activated by an automatic switch and manual action without cut-off.
- ✓ 2x manual bypass for maintenance operations.
- ✓ Microprocessor control.
- ✓ Alarms and signal panel.

The UPS and distribution cabinets shall be of the self-supporting metal type, for floor mounting, with IP54 protection level. The cabinets will be accessible from the front and cable entries will be made from the bottom part of said accesses; they shall include fixed circuit breaker switchgear.

### 7.8.19. Backup Power System (Emergency)



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In the event of a prolonged power failure or disconnection from source, the installation of an alternative generator set is recommended, to allow the facility's essential electrical loads to be supplied.

Essential electrical loads are: the membrane displacement pumps, distributed control system, lighting and power outlets system, air compressing services, the hydraulic compressor, motor valves, overhead cranes and cranes, air conditioning and firefighting systems.

The study and sizing necessary for the installation of a backup power system are beyond the scope of this assessment study, and can be incorporated in the later project stages.

### 7.8.20. Cable Troughs

Independent cable layouts shall be projected for medium and low voltage, control and instrumentation lines.

The best installation method shall be provided for the various cable layout situations, according to the need presented.

#### 7.8.20.1. Cabe Trays

The cable trays to be installed in indoors must be the ladder type and made of pultruded fiberglass, for light and heavy cables, and must be manufactured in accordance with the Brazilian electric sector rules. The tray supplies must include all installation accessories.

The cables shall be arranged in a straight layout, to preserve their positions relative to each other, avoiding jamming. Entrances and exits shall be executed in a way that does not prevent the maintenance of existing cables or the installation of new ones.

Each circuit shall have clamping flanges to hold the phases together, so that thermal and thermodynamic stress, due to the different conditions that may arise during plant operation, cannot move or deform them.

The cables shall be tagged into the trays at 5-meter intervals, with their corresponding circuit.

#### 7.8.20.2. Perforated cable floor duct

When necessary, masonry gutters may be used for cable wiring indoors. The gutters must have floor grating for cable protection in the pathway and must be dimensioned according to the gauge and number of passage circuits.

#### 7.8.20.3. Outdoor drainage ditch pipes

The cables shall be embedded in ditches under a pipe on the soil, arranged in layers. The ditch's minimum depth will be 600 mm to avoid any plumbing under the pavement, and 800 mm under the road.

Ditch dimensions will vary depending on the services found (water, gas, etc.) and number of circuits. A signaling tape will be placed along the piping to warn of the existence of electric wiring and its mechanical protection elements (polyethylene tiles). Ditch routes will be clearly marked and identified.

Regulatory safety distances shall be maintained in parallel and intersections with other services (power lines, communications, water or gas). In the case of road intersections or roads with traffic,



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the cables will be installed under a fiber cement tube with a 150mm diameter. In all cases, two free pipes will be provided with pre-installed guidewires for future installations.

Pipeline layout will be as straight as possible and parallel to fixed references, such façade lines and guides, avoiding changes in direction.

#### 7.8.20.4. Exposed Electrical Conduits

In case of exposed electrical conduits, wiring will be housed in a galvanized steel tube in accordance with NBR 5597 and 5598, for surface mounting with an anti-corrosion finish and C4 classification. The log boxes shall be installed every 15 m, at most.

Only curves shall be allowed for layout deviation, and it is strictly forbidden to subject conduits to heat. The conduits must be supplied with a threaded sleeve at one end. Such ends, when not threaded directly into housings or connections with their own female thread or stop limiters, must necessarily have bushings, washers, or die cast zinc Zamacs.

The conduits must be dimensioned according to NBR 5410.

#### 7.8.20.5. Unexposed Electrical Conduits

In the case of layout through unexposed conduits, the wiring will be housed in a rigid PVC pipe, self-extinguishing and threadable, according to NBR 6150.

Only curves shall be allowed for layout deviation, and it is strictly forbidden to subject conduits to heat. The conduits must be supplied with a threaded sleeve at one end. Such ends, when not threaded directly into housings or connections with their own female thread or stop limiters, must necessarily have bushings, washers, or die cast zinc Zamacs.The conduits must be dimensioned according to NBR 5410.

### 7.8.21. Lighting

Sufficient light spots will be installed to provide a lighting level that guarantees safe and efficient plant operation. Installation will guarantee the following average lighting levels:

| Location | Lighting level (lux) |
|---|---|
| Control rooms and laboratories | 500 |
| Offices | 500 |
| Electrical rooms | 500 |
| Indoor process areas | 400 |
| Outdoor process areas | 200 |
| Service galleries | 150 |
| Warehouses | 200 |
| Workshops | 300 |
| Hall, hallway, bathrooms, dressing rooms and service areas | 150 |
| Roads and parking | 50 |



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The types of fixtures to be installed were defined according to the type of facility, ceiling height, areas and environment. The fixtures must be arranged in a manner to ensure maximum lighting uniformity and so that lamp replacement can be done without risk of contact with other voltage elements.

Maintenance of all lighting equipment must be done without the need to assemble complex structures. Fixtures will have a maintenance factor of 0.7.

#### 7.8.21.1. Indoor Lighting

The essential service bars supply general lighting for each zone. From this point, different outlets will be made to the local lighting boxes in the buildings. A normal and an emergency lighting installation are planned.

The lighting distribution will be 3-phase, and the areas illuminated by more than one circuit will be fed by different phases. All lighting circuits will be protected by circuit breakers and 30 mA of sensitive and instantaneous response differential protection.

The administrative building lighting will be done through independent mechanisms, keys and pushbuttons. The interior processing, electrical room, workshop and warehouse areas will be controlled from the control room. The mechanisms will be housed in a synthetic material (PVC) box, which will vary according to the risk of each location. In the case of processing rooms and laboratories, the pushbuttons will be IP 65, watertight and have a lid. They will be installed on the surface, as close as possible to the access doors.

The types of fixtures provided are the following:

- ✓ In processing and electrical rooms less than 4 m high, watertight IP65 fixtures for surface mounting equipped with 2x18 W LED lamps shall be installed.
- ✓ In process rooms over 4 m high, watertight IP65 fixtures suspended from the ceiling, of the industrial hood type and equipped with LED lamps, shall be installed at 150 W.
- ✓ In the offices and control room areas, built-in screens, with V-slatted grids, equipped for 2x18 W LED lamps shall be used.

Emergency lighting will automatically come into service when normal supply fails. An average lighting level of 5 lux was considered for evacuation routes, tables and/or equipment used to perform any type of maneuver, inspection or measurement.

The installation of emergency lighting will be done with watertight autonomous fixtures and 3.5W LED lamps, 230 V power and a nickel-cadmium battery with 1-hour minimum autonomy.

#### 7.8.21.2. Outdoor Lighting

The outdoor lighting installation includes the streets and external processing areas: pre-treatment, post-treatment and product water tanks.

Outdoor lighting control shall be executed by time switches and photocells.

Cylindrical columns in galvanized steel sheet, 6 m high, with spherical waterproof IP65 fixtures, equipped with 150 W LED lamps and anti-vandal polycarbonate closures were elected to compose street lighting.

In the pre-treatment, post-treatment and product water tank working areas, 6 m lighting posts with 400 W LED projectors will be installed.



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### 7.8.22. Power outlets

The outlets shall comply with the IEC60309 standard provisions. The lighting switchboards and outlets shall be independent of each other.

A minimum of two single-phase, 220 V, F + N + PE, 16 A socket outlet boxes shall be installed per room in administrative buildings.

In the process areas and electrical rooms, sockets with 400 V, 3P + PE, 32A power outlets shall be installed for the operation of portable, welding and similar equipment; these outlets shall have two single-phase 220 V, F + N + PE and 16A capacity sockets, for various uses.

The outlet boxes shall be made of synthetic material, containing a lid and IP65 protection level. They shall be distributed throughout all areas, located close to the main equipment with a maximum distance of 25 m between two outlets.

The power circuits will be protected by an automatic circuit breaker, differential protection sensitivity and 30 mA instantaneous action.

### 7.8.23. Grounding

The main objectives to install a grounding system are:

- ✓ Ensure safety so that people are not exposed to dangerous electrical stress on a permanent basis or under conditions of failure.
- ✓ Protection of the facility, in case of power failure, ensuring an impedance low enough to facilitate correct protection device operation. Maintenance of system voltages within adequate limits, to avoid a dielectric breakdown of insulation.
- ✓ Create an equipotential grounding platform on which electronic equipment can operate. Provide an alternative path for induced currents, so electrical noise in the cables is minimized.

Grounding projects shall comply with the ANSI / IEEE-80 Standard provisions.

The grounding grid shall have a resistance less than or equal to 5 Ohms at the electrical network and 1 Ohm at the 69/6.6kV Substation, which guarantee adequate contact and step voltages.

The grounding system shall consist of at least the following:

- ✓ Protective grounding for plant equipment
- ✓ Transformer neutral grounding
- ✓ Lightning rod grounding
- ✓ Instrumentation grounding

These grounding systems will be joined together to form a single equipotential surface.

The grounding system dimensions shall be calculated considering the maximum fault current in the most unfavorable conditions, in magnitude and fault release time, characteristics and soil resistivity values.

When there are high soil resistivity conditions, special chemicals or additives will be used to improve these values to achieve regulatory compliance.

The grounding system installation shall consist of an underground and overhead network of protective conductors.


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The underground network consists of a series of 3 m long buried steel-copper rods, joined together by a 50 $mm^2$ bare, soft copper cable (with a 95 $mm^2$ section at the 69/6.6kV Substation), forming a buried grid in direct contact with the ground.

In buildings and machine areas, cable grounding shall be connected to the reinforcements, pillars and structures.

The overhead network will be formed by 35 $mm^2$ section copper protective conductors, which shall join the mechanical equipment, such as benches, tanks and surface structures to the buried network. The electric motors will be grounded through the protective conductor part of the power supply. The cable metallic shielding shall be grounded.

The lighting column circuits in the external areas shall have their own grounding with a 35 $mm^2$ section cable, and a 2 m boom will be installed next to each.

All splices, shunts and cable joints will be made with aluminothermic welding.

### 7.8.24. Protection Against Electrical Discharges and Overvoltage (*SPDA*)

In order to mitigate the damage that can be caused by lightning impact on the building's structure, its occupants and equipment, a lightning protection system must be installed.

Sizing for the lightning protection system must be determined in accordance with IEC 62305; the components and materials used must comply with IEC 61643 and IEC 50164.

The lightning protection system must consist of:

- ✓ A lightning arrester system that will be installed at a certain height above the highest points of the buildings, structures or installations to be protected. An active arrester system with a priming device (PDC) was selected. Active and passive systems (Franklin rods and capture meshes) can coexist. In this way, if there is a high-risk structure or area outside the planned protection zone, both systems can be combined to cover all areas.
- ✓ System to conduct the electrical discharge to the earth by drawing two independent paths, to ground with the shortest possible length.
- ✓ A grounding electrode conductor to adequately dissipate electrical discharges.

To obtain full protection against overvoltage events, the system must consist of an external protection system against direct lightning and an internal protection system. Overvoltage protection will be installed on the distribution switchboards, which guarantee the protection of the equipment connected to the facility.



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# 8. Architectural Project

## 8.1. Introduction

The seawater desalination plant is located in Fortaleza, Ceará, at the Praia do Futuro I District, bordering streets Francesco de F. Dângelo, Raimundo Esteves, Oliveira Filho and Pinto Antônio Bandeira. It corresponds to a regular land plot formed by two partially unoccupied blocks, separated by an unconsolidated street. The total area corresponds to 2.3 ha, where 2 hectares correspond to the two blocks. The nautical charts indicate a depth of 14.0 m at a distance of 2.5 km from the coast.

The complex consists of a series of buildings, including the Process Building, the Administrative Building, the Collection Chamber, the Final Product Reservoir and Pumping Station.

These are described below, taking into account their respective locations within the plot, functions and construction suggestion.

## 8.2. Process Building

### 8.2.1. Location

The Process Building is located at the site's center.

### 8.2.2. Function

Among others, the Reverse Osmosis rack, cartridge filters, filter washing pumps and chemical cleaning system shall be located in this building.

### 8.2.3. Construction

The building consists of a metallic structure, with a roof sandwich composition composed by two curved metal panels and a Galvalume steel trapezoidal panel with interior rock wool and adequate treatment according to its proximity to the sea and high sea spray corrosion.

The façades shall also bear the same metallic panel sandwich roof system, with rock wool in its interior and two colors, gray and white. It shall receive treatment according to its proximity of the sea and high sea spray corrosion.

It shall have a basement in concrete block, with plaster and paint in concrete gray color.

The interior floor shall be in smooth concrete with epoxy resin.

## 8.3. Administrative Building

### 8.3.1. Location

Connected to the Process Building, at its northwestern side.

### 8.3.2. Function

The Administrative Building encompasses the following spaces in FLOOR 00:

- ✓ Entrance with Reception, connected to the Process Building, the personnel area with changing rooms and FLOOR 1
- ✓ Male and female restrooms and changing rooms (connected to the reception)
- ✓ Mechanics Workshop (connected to the Process Building)
- ✓ Electrical Workshop (connected to the Process Building)
- ✓ Warehouse (connected with the outside).



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- ✓ Electrical Room and Transformation Station (connected with the outside)
- ✓ Brine Reservoir
- ✓ Auditorium area for approximately 180 people (access from the outside, and connection to the Water Museum, on the top floor)

At FLOOR 1, the program consists in:

- ✓ Laboratory with kitchen, male and female restroom facilities, 01 office and file room
- ✓ Floor Support Sanitary Facilities
- ✓ Observation Room
- ✓ 05 offices
- ✓ Meeting room for 12 people
- ✓ Control Room
- ✓ Water Museum

There are also 09 outdoor parking spaces available for light vehicles and 02 parking spaces destined to the transportation of visiting passengers.

### 8.3.3. Construction

Beam column and reinforced concrete slab structure system, with a glass front southeast façade, composed of a Stick system with Gray RAL 9006 finish and laminated glass in a neutral color.

Occasionally, in FLOOR 0, some glass panels in this façade may be replaced by opaque ACM panels to opacify technical areas.

The roof is in concrete slab covered with waterproofing screens and thermal insulation.

## 8.4. Intake Building

### 8.4.1. Location

Located on the South side of the land plot.

### 8.4.2. Function

Intake building, electrical room, pump room.

### 8.4.3. Construction

Beam column and reinforced concrete slab structure system, with concrete block walls, plastered concrete and gray concrete paint. A concrete slab roof covered with waterproofing screens and thermal insulation, with a trapezoidal sheet covering with treatment adequate to the building's proximity to the sea and to sea spray corrosion.

## 8.5. Final Product Water Storage and Pumping Station

### 8.5.1. Location

Located at the land plot's entrance, in the northwest area.

### 8.5.2. Function

Final product reservoir and pumping station.

### 8.5.3. Construction


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Reinforced concrete structure, painted with a gray concrete color. Concrete slab roof covered with waterproofing screens and thermal insulation.

# 9. Plant Instrumentation and Control

## 9.1. Instrumentation and Control System Communication

The necessary field instruments will be installed to perform the facility's assessment, operation, shutdown, control and supervision and to identify equipment status for its maintenance. Field instrumentation shall not only provide the corresponding signal to the control system, but also have local records, in engineering units, of the variable value, to allow identification of its value "in situ". In the same way, it shall have a display with a keyboard to identify other values, such as totalizers, measurement ranges or others.

The local instruments deemed necessary shall also be installed to determine field operation status, regardless of the existence of control and indication of the same variable. Among others, the installation of pressure gauges on pump suction and discharges sites, a local thermometer for seawater temperature measurement before the racks' entry shall be considered. Storage tanks for any product and chemicals shall have a local liquid level indication through visual verification and level transmitters.

The instruments shall not be mounted directly on the tube. A frame shall be built where the instruments that must be physically close must be mounted. Manometers, pressure switches and pressure transmitters or differential pressure transmitters must be equipped with an adequate isolation valve, depending on fluid and pipeline pressures. They shall also have an air release valve to allow elimination of air trapped in the instrument. Likewise, they shall be assembled with a membrane to separate the fluid to be measured. Pressure transmitters and differential pressure gauges shall be equipped with a valve set suitable for isolation, equalization and purging operations, to prevent membrane rupture during instrument assessment.

The process data communication network between controllers, remote I/O offices and field instruments will be controlled through Fieldbus in Profibus DP optical fiber.

The bus shall allow transmission speeds of up to 12 Mbit per second.

The system will be able to read all variables generated by field devices without the need for additional wiring. Field devices will provide all diagnostic information, including device and configuration failures, mode of operation and maintenance requests.

The system will allow connection of all field devices certified by the standards organ corresponding to this type of field bus, and shall not require additional approvals from the main system manufacturer.

The system will allow fieldbus communication at H1 (lower speed, device powered by the bus) and H2 (high speed, high bandwidth) levels, using a single communication protocol that minimizes the need to use multiple configuration tools.

The design, assembly and instrument and control testing and their auxiliary systems must comply with ISA, NEMA, IEE provisions or equivalent standards. They must also comply with all requirements of electromagnetic compatibility standards IEC 61000-4-2, 61000-4-3, and 61000-4-4.


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Due to the distance from the Plant to the DELIVERY POINTS, a radio or equivalent solution must be provided for transmitting data from the sensors installed at those points to the Plant Control System.

## 9.2. List of Field Instruments

Instruments installed in a desalination plant are typically:

- ✓ Flow measurement instruments in:
  - Seawater pumps
  - Filtration of each filter
  - High-pressure pump feed
  - Feed to the recovery system
  - Brine recirculation
  - Permeate water per rack
  - Total plant production
  - Tank connection pump
  - Water flows provided at DELIVERY POINTS
- ✓ Instruments for pressure measurement at:
  - The impulses of each pump
  - The entrance and exit of each osmosis pass
  - The permeate collector outlet
  - At DELIVERY POINTS
- ✓ Instruments for level measurement at:
  - Chemical storage tanks
  - Chemical cleaning and displacement tanks
  - Collection chamber
  - Product water reservoir
- ✓ Temperature measurement instruments at:
  - At osmosis rack inlets
- ✓ Float level, contact and pressure switches.
- ✓ Analytical instruments
  - To measure turbidity
    - ➢ Before and after pre-treatment
    - ➢ At the product water outlet
    - ➢ At DELIVERY POINTS
  - Conductivity measurements at:
    - ➢ Seawater inlets
    - ➢ Permeate collectors from each rack
    - ➢ Osmosis racks inlets
    - ➢ Brine discharge
    - ➢ Product water collector
    - ➢ At DELIVERY POINTS
  - For pH measurement at the:
    - ➢ Seawater inlet
    - ➢ Filtration outlet
    - ➢ Permeate collector



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- Brine discharge from the neutralization tank
- Product water collector
- At DELIVERY POINTS

- To measure Redox potential, ORP
  - At the seawater inlet
  - At the permeate collector from each rack
  - Inlet to osmosis racks
  - At the brine discharge from neutralization tank
- For chlorine measurement
  - At the seawater inlet
  - At the product water collector
  - At DELIVERY POINTS
- Others: hydrocarbon, hardness, silica content and SDI meters, etc.

## 9.3. Control System

The Process Control System will be executed through a Distributed Control System (DCS). It shall contain different signal concentration offices with I/O cards, distributed throughout the desalination plant, two PCUs with real redundancy, the work sites, associated software and communication networks between various elements.

The equipment must meet all the requirements of electromagnetic compatibility standards IEC 61000-4-2, 61000-4-3, and 61000-4-4.

The proposed supervision and control systems consist of the following levels of control:

- ✓ Level zero, or data acquisition and local control level. This level shall correspond to instrumentation and field control.
- ✓ First level, or the sequential control that corresponds to the plant's logic controllers (PLCs). Its functions are:
  - Data acquisition (analog variables and equipment status reading)
  - To create events and alarms (depending on process inputs analog variable measurements)
  - Interlocks and operating sequences surveillance (with creation of alarms in non-compatible situations)
  - Start/stop, open/close the device. With interlocks surveillance. These commands can be executed according to the PLC's internal program or depending on a command from the central supervision system.
  - Operation loops

  This level works autonomously, that is, it works without communication, making its own programmed decisions.

  The remaining zone controllers shall be installed as close as possible to the signal transmission elements. The central controller and periphery of the distributed zone communicate via Ethernet, through the fiber optic ring.
- ✓ Second level, or Supervision: this level is executed in the supervisory PCs control room, where the supervision software is located in the Windows operating system. From this level, one can:
  - Visualize all field elements (states, analog values, etc.)
  - Visualize historical data (trends, alarms, etc.)


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- Change data, slogans or process parameters
- Place remote requests for field staff
- Create reports
- Obtain equipment and system information (electrical diagrams, incident sheet, etc.), through a link with the management application.

The facility shall have its own control room, where the operation and engineering stations and servers will be installed.

At the operation and engineering stations, the graphic interface (HMI), created based on specific programs for this purpose, will be available for data visualization, commands, alarms, process control, events, facility maintenance and operation reporting.

The screens will be interactive, based on menus, hierarchically structured, representing the Plant's general level until the points level.

Two (2) redundant servers shall be included for real time data and history data storage. One (1) operating station and one (1) engineering station will be included. Each workstation shall consist of two (2) 27" monitors, optical mouse, keyboard and PC with the latest generation hardware and high-performance Windows operating system. Communications will be made through Industrial Ethernet.

It will include all the software and licenses necessary for the proper operation of each workstation, including: Windows operating system, Microsoft Office (Word, Excel and Access), antivirus programs.

The Process network communication between PLC controllers and the operating stations shall happen through the Ethernet, with optical fiber as a support. Data transmission shall done by baseband with a minimum speed of 15 Mbits per second. The network protocol will be TCP/IP.

Communication between the main controller and the remote I/O offices will be done through a fiber optic Fieldbus of the PROFIBUS (DP and PA) or Fieldbus Foundation type. The Fieldbus shall allow transmission speeds of up to 12 Mbit per second.

## 9.4. Communications Network

There will be a telephone exchange and an internal telephone network to allow communication between different rooms and areas of the desalination plant. Internal telephones will be installed in the control room, offices, etc. The tone shall be louder considering the noise level of each area. Several telephones shall be distributed to facilitate communication, according to the extension of the workplace.

## 9.5. Video Surveillance Network

A perimeter Video Surveillance Network will be installed on the desalination plant's premises and interior, with recording capabilities (DVR). The main access door shall also have an intercom with a control room with an automatic door.

It also contemplates the installation of a perimeter security system that prevents people outside the plant from trespassing.

The Control System Diagram is shown below.



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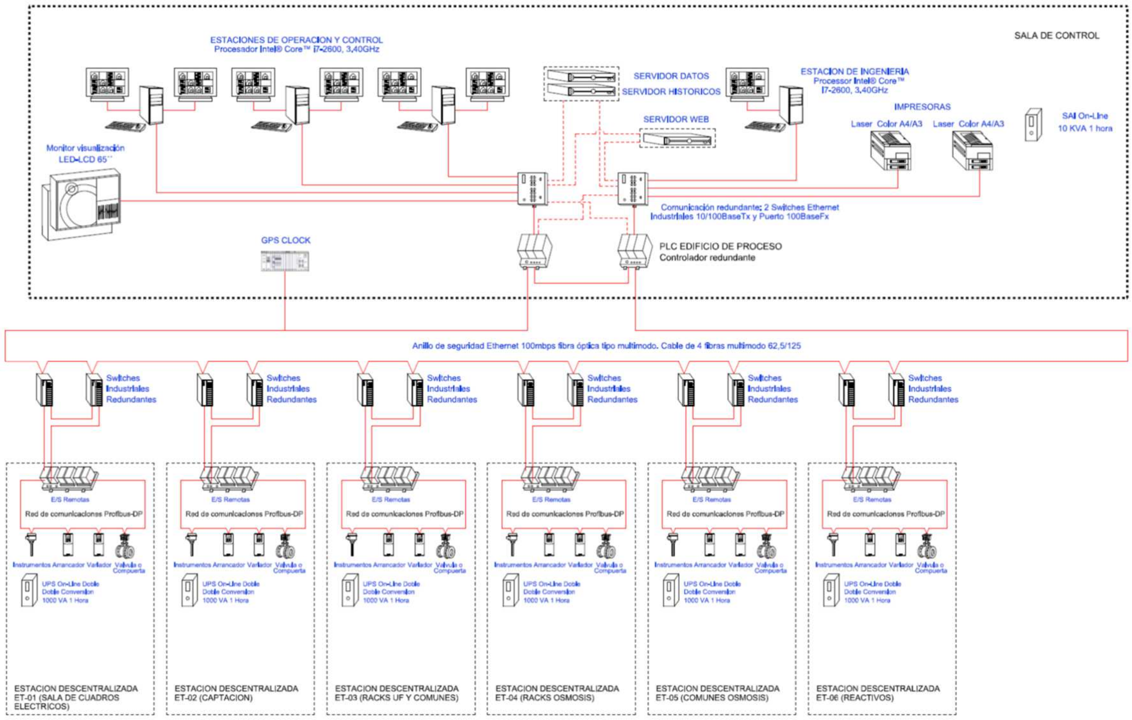




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# 10. Connection with CAGECE's Macrodistribution System

## 10.1. General Condition

In meetings between the technical team and CAGECE, the most efficient plan to incorporate the water produced in the desalination plant into CAGECE's general water distribution system was discussed and defined.

This study was executed considering the General Configuration of the Intake System and the distribution that CAGECE has in operation, current transport capacities, global demand values by distribution zones and altimetric level, characteristic reservoir storage and the system's general effectiveness and weaknesses.

It is important to note that this new water source, which shall increase CAGECE's availability by a large daily volume (1 $m^3/s$), will be located at one end of the system and where direct demand values from the altimetric levels will not be enough to consume this new volume in the short term.

## 10.2. General Configuration of the Intake System

The general configuration of the injector system determines that all the water produced by the desalination plant shall have as its objective to satisfy the demands of the Mucuripe and part of the Aldeota branches, currently supplied by the Ancuri reservoir.

The desalination plant's interconnection to the Cagece system will be executed directly from the Aldeota and São Pedro branches distribution networks, as well as from the Mucuripe reservoir.

In this manner, the treated water pumping station shall be built consisting of four active pump sets and one reserve/replacement. The pressure main starts at the desalination plant and extends for about 1,343 km, in HDPE DN1000 mm; from this point, the pipe will be divided into two different sections: one that will go to the Mucuripe reservoir, with a length of 1,196 km, in HDPE DN710mm, and other that will continue to the Aldeota branch with an approximate length of 5.277 km, in HDPE DN800mm.

The interconnection with the system shall happen in two different ways in the Mucuripe branch: through a direct interconnection to the São Pedro branch's distribution network, in a preexisting FoFo DN400mm pipe, and the interconnection with the Mucuripe Reservoir, from where the supply to the Papicu, Varjota, Cidade 2000, Praia do Futuro, Caça e Pesca, Cais do Porto (Serviluz) and Vicente Pinzon districts shall happen. The Mucuripe branch will receive a flow of around 400 L/s from the desalination plant, and the surplus produced will be sent to the Aldeota branch.

The interconnection with the Aldeota branch shall take place through the injection into an existing steel DN700mm distribution network, from where it extends to supply the sector. In a standard operating situation, the Aldeota branch will receive a flow of approximately 600 L/s of the water produced by the desalination plant. However, the pipeline that shall interconnect with the branch was sized so that, in special situations, it can transport 1000 L/s.

Flow and pressure meters will be installed at the point of arrival of the pipelines from the desalination plant, in the Mucuripe (before leaving for the São Pedro branch) and the vicinity of the Aldeota reservoir, as well as in the plant's outlet.



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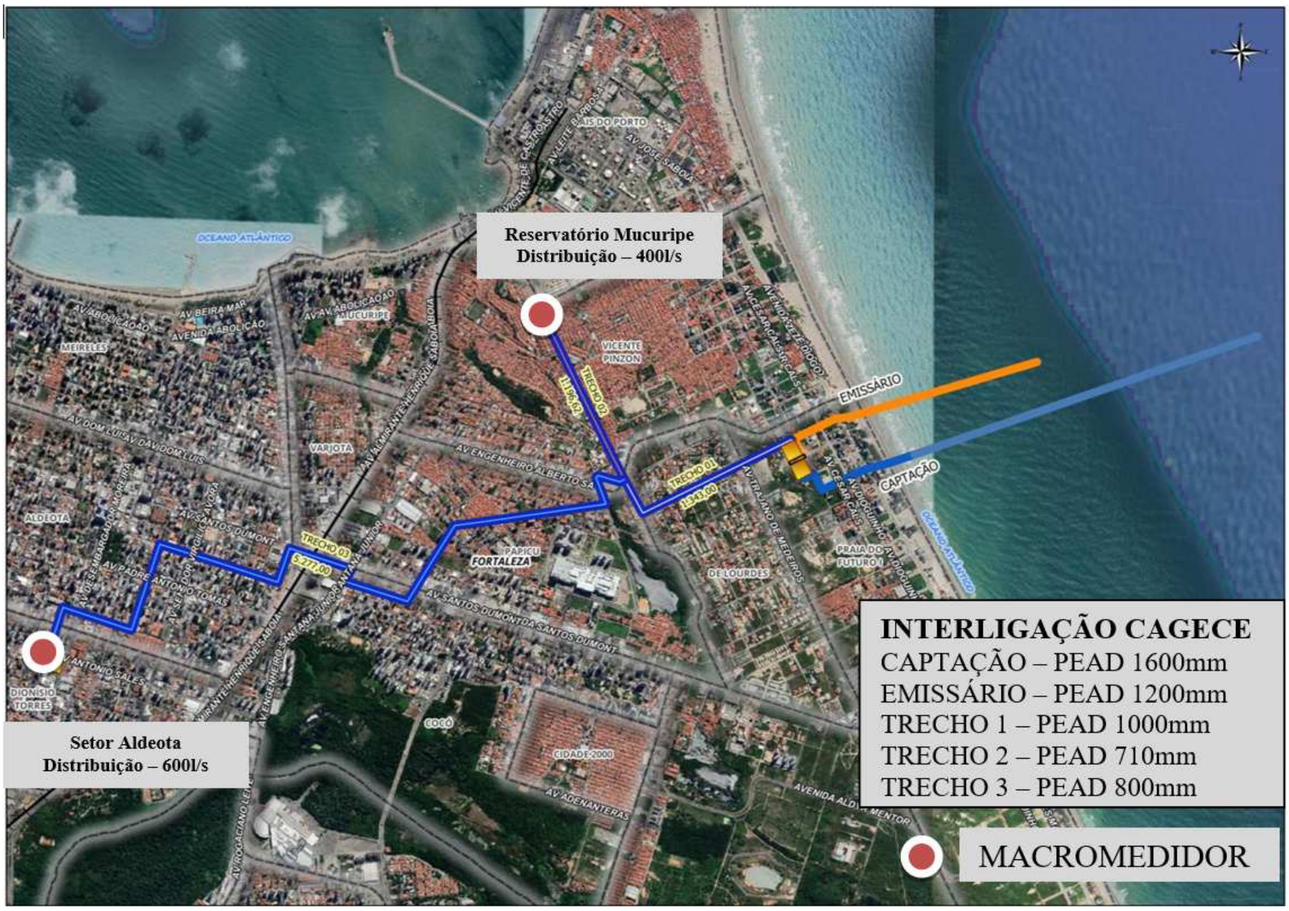
The scheme configuration of main line interconnections of the desalination plant with the existing macrosystem, as well interconnection details of these lines with the Mucuripe and Aldeota branches are presented in the following drafts.

Figure 10.1 - Intake System Scheme Configuration



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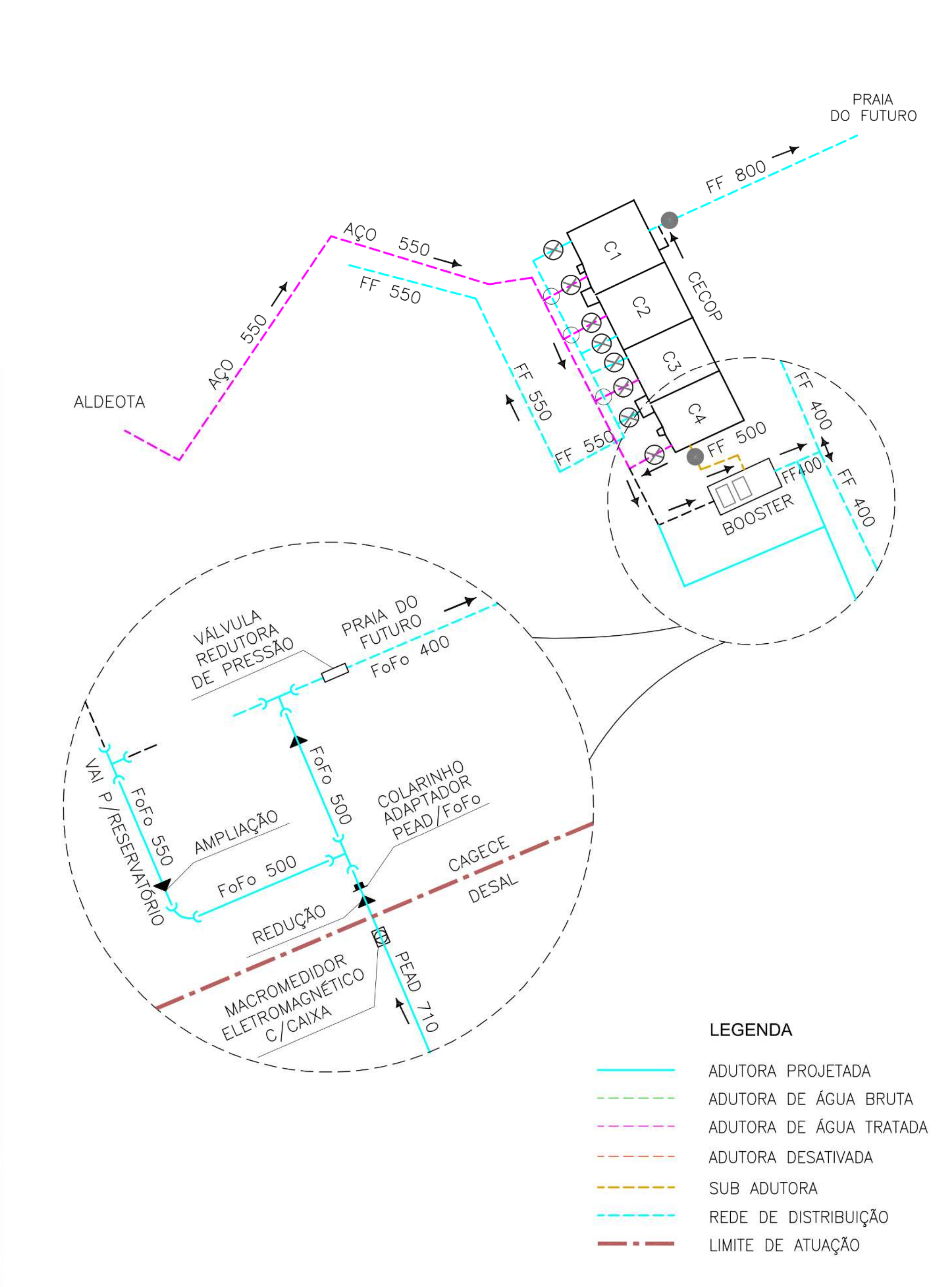
# PLANTA DE DESSALINIZAÇÃO DE ÁGUA MARINHA

## INTERLIGAÇÃO DESAL – MUCURIPE



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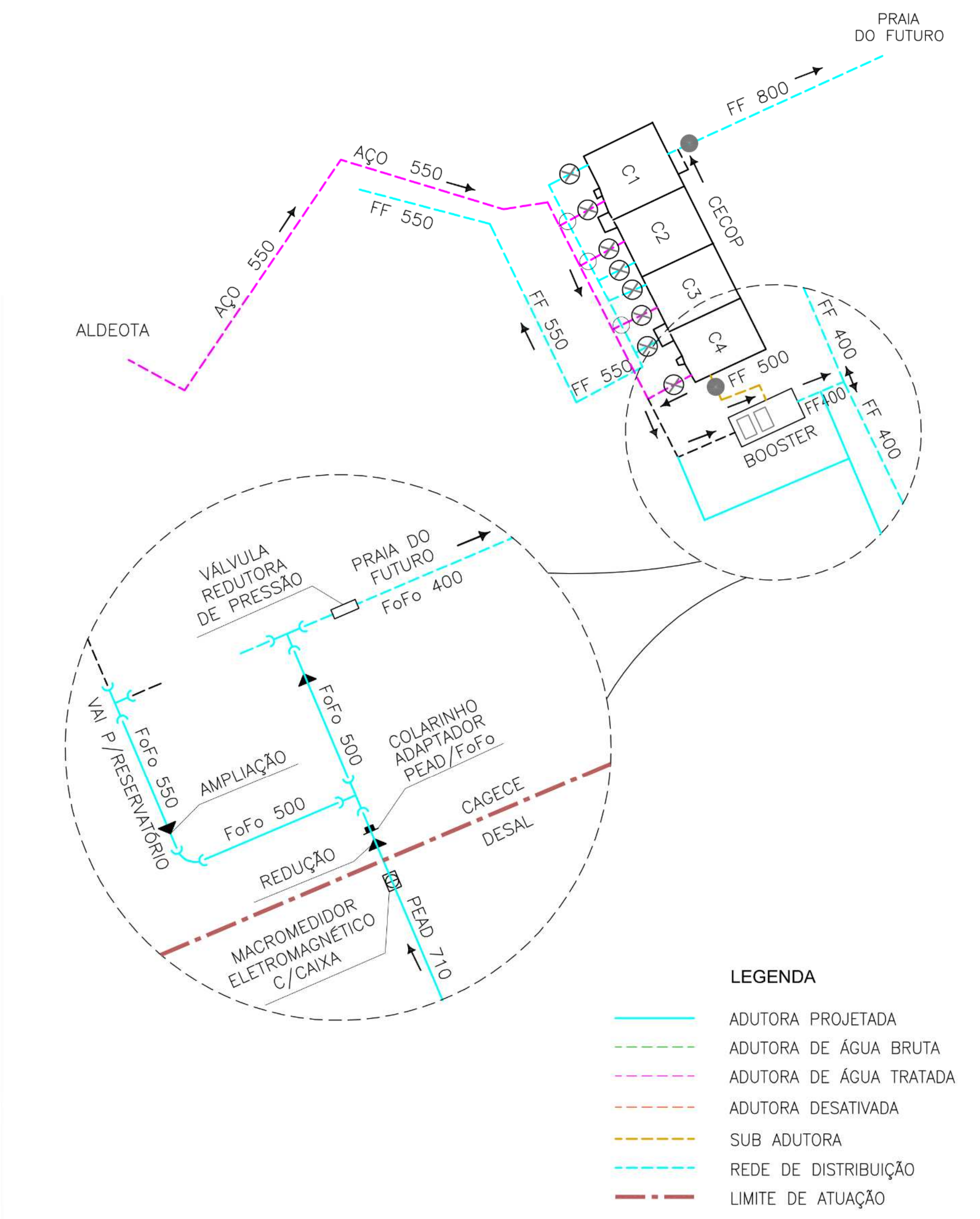
COMPANHIA DE ÁGUA E ESGOTO DO CEARÁ

# PLANTA DE DESSALINIZAÇÃO DE ÁGUA MARINHA

## INTERLIGAÇÃO DESAL – MUCURIPE



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The budget for the interconnection with the CAGECE system are presented below.

| CAGECE - PMI DESSALINIZAÇÃO FORTALEZA - 1m³/s | | |
|---|---|---|
| PLANILHA ESTIMATIVA - ANTEPROJETO | | |
| ITEM | DESCRIÇÃO DOS SERVIÇOS | PREÇO TOTAL (R$) |
| | PMI DESSAL FORTALEZA | 484.486.896,89 |
| 2 | CONDUTAS ELEVATÓRIAS (INTERLIGAÇÃO COM REDE CAGECE) | 83.660.927,49 |
| 2.1 | SERVIÇOS PRELIMINARES (INCLUI MOBILIZAÇÃO/ADMINISTRAÇÃO LOCAL) | 10.434.732,75 |
| 2.2 | CANTEIRO DE OBRAS (INCLUI CONSTRUÇÃO DE CANTEIRO E MANUTENÇÃO) | 5.424.162,57 |
| 2.3 | TUBULAÇÕES E EQUIPAMENTOS - TRECHO 1 - PEAD DN 1000 | 11.278.180,80 |
| 2.4 | TUBULAÇÕES E EQUIPAMENTOS - TRECHO 2 - PEAD DN 710 | 7.163.628,05 |
| 2.5 | TUBULAÇÕES E EQUIPAMENTOS - TRECHO 3 - PEAD DN 800 | 49.360.223,32 |

## 10.3. Pumping station

### 10.3.1. General Considerations

In accordance with the general transportation configuration presented in the previous section, the treated water pumping station shall be built next to the product water reservoir. This infrastructure shall be installed inside the plant's perimeter and be responsible for transportation of water to the Mucuripe and Aldeota branches.

The treated water pumping station is designed to increase the flow of 1000 L/s to a manometric head of 76.2 m, corresponding to the geometric difference between the pumping station and the delivery locations, considering total pressure system losses.

### 10.3.2. Equipment

#### 10.3.2.1. Motor-pump groups

The main technical characteristics of the proposed motor-pump sets are described in Table 10.1.

Table 10.1 - Main characteristics of the motor-pump group suggested - EEA-01

| | |
|---|---|
| Brand | HIGRA |
| Model | R2-390 B |
| Total flow ($m^3$/h) | 3600 $m^3$/h |
| Unit flow ($m^3$/h) | 900 $m^3$/h |
| Manometric head (mca) | 76.2 mca |
| Total number of sets | 5 |
| Number of sets in operation | 4 |
| High-pressure pipe diameter (mm) | 300 |
| Suction diameter (mm) | 300 |
| Motor power (cv) | 400 |
| Rotation (rpm) | 1750 |
| Efficiency (%) | 72 |



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#### 10.3.2.2. Piping

The piping to be installed in the lifting stations will be made of ductile cast iron, in some places equipped with support “cradles”. The pipes will make the connection between the reservoir duct upstream of the pumping station and the general suction manifold, common in the motor-pump groups. They shall also connect the general compression manifold, common to all groups, and the high-pressure pipelines, including the interconnections inside the station.

The general suction manifold will be equipped with taps for the individual suction pipes of the motor-pump groups. Each pipeline shall allow the assembly of an isolating valve and a pressure gauge (pressure switch).

At the pumps’ outlet, each of the individual compression pipes will be prepared to allow the assembly of check and sectioning valves. The general compression piping will be equipped with bypasses for the pumps, a hydropneumatic tank and a pressure gauge.

#### 10.3.2.3. Valves

The pipes shall be equipped with valves of various types, to allow maintenance operations, for safety or operational reasons and also to interfere with starting and stopping pump conditions.

The section valves shall be of the butterfly type and installed in the suction and compression pump lines, in accordance with the designed parts.

## 10.4. Intake pipelines

### 10.4.1. Hydraulic sizing

Sizing of the pressure main between the desalination plant and the connection spot in the Aldeota branch was projected for a flow of up to 1000 L/s, while the section that leads to the Mucuripe Reservoir was sized for a maximum flow of 500 L/s, to guarantee a minimum pressure of 15 mca at the Aldeota branch connection and 25 mca at the Mucuripe Reservoir.

Table 10.2 – Gravity and Pressure Line Sizing

| | | Pressure Conduction | | |
|---|---|---|---|---|
| | | **Desalination Plant – Fork junction** | **Fork junction - Mucuripe** | **Fork junction - Aldeota** |
| Material | | PEAD | PEAD | PEAD |
| PN | | 10 | 10 | 10 |
| DN (mm) | | 1000 | 710 | 800 |
| DI (mm) | | 881.4 | 625.8 | 705.2 |
| $Q_{dim}$ (l/s) | | 1000 | 500 | 1000 |
| V (m/s) | | 1.64 | 1,63 | 2.56 |
| L (m) | | 1343 | 1196,62 | 5277 |
| Continuous Loss | Unit (m/m) | 0.001506 | 0.00251 | 0.00503 |
| | Total (m) | 2.02 | 3.00 | 26.54 |
| Site Losses (m) | | 3.11 | 0.12 | 1.77 |
| Total losses (m) | | 5.13 | 3.12 | 28.31 |



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### 10.4.2. Construction Provisions

Pipeline implantation was carried out based on a topographic survey on a 1/10,000 scale, supported by aerial photos made available by Google Earth.

The plan traces and longitudinal profile are displayed in the drafts at the 1/5000 (horizontal) and 1/500 (vertical) scales for the pressure and gravity pipes, also including locations for the accessories.

In the plan, some of the conditions caused by subsoil occupation are also identified, such as gas, water supply and drainage piping. This information does not present the necessary accuracy for the correct quantification, and is therefore merely informative.

In the profile layout, a minimum depth of 1.0 m from the superior generatrix was designed, to minimize the number of flush and air vent valves to be installed, as such amount is often exceeded.

A minimum slope of 2% was considered in the longitudinal profile draft.

The longitudinal profile draft includes the following information:

- ✓ Location of accessories (discharges, air vent valves);
- ✓ Terrain dimensions, piping sill dimensions and sill depths;
- ✓ Diameter, material and section slopes;
- ✓ Profile number;
- ✓ Distance to the origin and between profiles.

All accessories necessary for the execution of the defined plan are indicated in the drafts.

The conduit pipes will be laid in a trench, at the depths defined in their respective longitudinal profile. The cross-section trench type is displayed in the drafts presented, where the pipe layout and constitution of the various trench layers are defined. Among these, one shall consist of material from the ditch, free of rocks; in the case this is impossible because the soil is rocky, it shall consist of clay obtained from a different site.

### 10.4.3. Equipment

For the proper operation of the intake system, it is necessary that some equipment is installed, such as section, flush bottom and air vent valves.

#### 10.4.3.1. Section and Flush Bottom Valves

The flush bottom valves allow the pipe to be emptied and must be installed at the low layout sites, downstream of the section valves in the upstream sections and upstream of the section valves in the downstream sections.

The section valves allow sectioning of the duct for maintenance or system operations. For this purpose, this equipment is installed along the pipeline, adopting, in general, distances between 2 to 4 km.

Considering the general flush and section valve location principles, the mains’ altimetric layout and the advantage that, in the flushes, only one of the two respective sections can be unloaded, it was found to be advantageous to assemble the organs and the section and flush functions in the same site.

The Draft Nr.70 – FLUSH VALVE DETAILS (DETALHES CAIXA DE DESCARGA) displays the project for the section and flush bottom valves.

#### 10.4.3.2. Air Vent Valves


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The air vent valves must be installed in the pipe to allow the release of air in the duct, which can result in cavitation.

The air vent valves to be installed in "high points" of the pipelines shall have three functions (sometimes called double effects), that allow:

- ✓ Expulsion of small amounts of air, that, when released during the system's permanent operation, accumulate in the high areas;
- ✓ Large volumes of air to enter when, through simple maintenance (opening of flush bottom valves) or rupture, the pipes are emptied, to avoid exaggerating depressions;
- ✓ Exit of large volumes of air when the pipes are filled, either after installation or after repairs.

The air vent valves will be installed in buried boxes according to the part drawn on Draft Nr. 69 - AIR VENT VALVE DETAILS (DETALHES CAIXA DE VENTOSA).

### 10.4.4. Pipeline Anchoring

The pipelines shall be secured by mooring blocks.

As there are no stretches with slopes greater than 15%, the installation of anchoring blocks is not necessary.

The mooring blocks shall be built in concrete, class C3, reinforced with steel, class CA-50, to allow absorption and dissipation of hydrostatic impulses in the pipes in areas where accessories exist.

In this way, instability and duct separation in these more fragile areas are avoided. The project contemplates the implantation of these massifs in direction changes, either horizontal or vertical, that generate curves.  The location of the referred massifs is displayed in the implementation drafts.



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## 11. Work Schedule and Estimated Budget

| ITEM | SERVIÇOS | UNID | QUANT. | R$ | MESES | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 1 | PROJETO BÁSICO E EXECUTIVOS | GL | 1,00 | 8.098.601,03 | 16,7% | 16,7% | 16,7% | 16,7% | 16,7% | 16,7% | | | | | | | | | | | | | |
| | | | | | 1.349.767 | 1.349.767 | 1.349.767 | 1.349.767 | 1.349.767 | 1.349.767 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | ELABORAÇÃO DO EIA/RIMA E LICENCIAMENTO PRÉVIO | GL | 1,00 | 688.410,36 | 30,2% | 30,2% | 17,3% | 8,6% | 8,6% | 1,9% | 0,1% | 0,1% | 0,1% | 0,1% | 2,5% | 0,1% | | | | | | | |
| | | | | | 208.171 | 208.171 | 118.937 | 59.469 | 59.469 | 13.360 | 684 | 684 | 684 | 684 | 17.415 | 684 | | | | | | | |
| 3 | LICENÇA DE INSTALAÇÃO E OPERAÇÃO | GL | 1,00 | 486.302,28 | | | | | | | | | | | | | 44,5% | 37,4% | 10,9% | 3,6% | 3,6% | 0,0% | |
| | | | | | - | - | - | - | - | - | - | - | - | - | - | - | 216.296 | 181.973 | 53.128 | 17.355 | 17.355 | 194 | - |
| 4 | COMPENSAÇÃO AMBIENTAL E MONITORAMENTO DURANTE OBRA | GL | 1,00 | 3.401.820,76 | 0,0% | 0,0% | 0,0% | - | - | 7,1% | - | - | - | - | - | - | - | - | - | - | - | 7,1% | 3,0% |
| | | | | | - | - | - | - | - | 240.000 | - | - | - | - | - | - | - | - | - | - | - | 240.000 | 100.935 |
| 5 | INTERLIGAÇÃO À CAGECE | GL | 1,00 | 83.660.927,49 | | | | | | | | | | | | | | | | | | | 4,5% |
| | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.802.769 |
| 6 | CAPTAÇÃO DE ÁGUA E DISPOSIÇÃO DE CONCENTRADO | GL | 1,00 | 97.260.179,19 | | | | | | | | | | | | | | | | | | | 4,5% |
| | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4.420.917 |
| 7 | PLANTA/LAYOUT | GL | 1,00 | 54.338.505,29 | | | | | | | | | | | | | | | | | | | 4,5% |
| | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2.469.932 |
| 8 | EQUIPAMENTOS, MONTAGEM, TREINAMENTO E START-UP | GL | 1,00 | 222.321.493,96 | | | | | | | | | | | | | | | | | | | 4,5% |
| | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 10.105.522 |
| 9 | FORNECIMENTO DE ENERGIA | GB | 1,00 | 11.007.696,00 | | | | | | | | | | | | | | | | | | | 4,5% |
| | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 500.350 |
| 10 | ACABAMENTOS FINAIS | GL | 1,00 | 7.799.493,92 | | | | | | | | | | | | | | | | | | | |
| | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | TOTAL GERAL | | | 489.063.430,30 | 1.557.937 | 1.557.937 | 1.468.704 | 1.409.235 | 1.409.235 | 1.603.127 | 684 | 684 | 684 | 684 | 17.415 | 684 | 216.296 | 181.973 | 53.128 | 17.355 | 17.355 | 240.194 | 21.400.426 |
| | | | | | 0,3% | 0,3% | 0,3% | 0,3% | 0,3% | 0,3% | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 4,4% |
| | | | | | 1.557.937 | 3.115.875 | 4.584.579 | 5.993.815 | 7.403.050 | 9.006.177 | 9.006.861 | 9.007.545 | 9.008.229 | 9.008.912 | 9.026.328 | 9.027.011 | 9.243.308 | 9.425.281 | 9.478.409 | 9.495.764 | 9.513.120 | 9.753.314 | 31.153.739 |
| | | | | | 0% | 1% | 1% | 1% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 6% |

| 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | 100,0% |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 8.098.601 |
| | | | | | | | | | | | | | | | | | | | | | | | 100,0% |
| | | | | | | | | | | | | | | | | | | | | | | | 688.410 |
| | | | | | | | | | | | | | | | | | | | | | | | 100,0% |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 486.302 |
| 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 10,3% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 3,0% | 10,3% | 100,0% |
| 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 350.628 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 100.935 | 350.628 | 3.401.821 |
| 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | | | 100,0% |
| 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | 3.802.769 | - | - | 83.660.927 |
| 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | | | 100,0% |
| 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | 4.420.917 | - | - | 97.260.179 |
| 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | | | 100,0% |
| 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | 2.469.932 | - | - | 54.338.505 |
| 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | | | 100,0% |
| 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | 10.105.522 | - | - | 222.321.494 |
| 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | 4,5% | | | 100,0% |
| 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | 500.350 | - | - | 11.007.696 |
| | | | | | | | | | | | | | | | | | | | | | 50,0% | 50,0% | 100,0% |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.899.747 | 3.899.747 | 7.799.494 |
| 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.650.119 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 21.400.426 | 4.000.682 | 4.250.375 | 489.063.430 |
| 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 4,4% | 0,8% | 0,9% | 100,0% |
| 52.554.165 | 73.954.591 | 95.355.017 | 116.755.443 | 138.155.868 | 159.556.294 | 180.956.720 | 202.357.146 | 223.757.571 | 245.157.997 | 266.808.116 | 288.208.542 | 309.608.968 | 331.009.393 | 352.409.819 | 373.810.245 | 395.210.671 | 416.611.096 | 438.011.522 | 459.411.948 | 480.812.374 | 484.813.055 | 489.063.430 | 489.063.430 |
| 11% | 15% | 19% | 24% | 28% | 33% | 37% | 41% | 46% | 50% | 55% | 59% | 63% | 68% | 72% | 76% | 81% | 85% | 90% | 94% | 98% | 99% | 100% | 100% |



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Cagece Companhia de Água e Esgoto do Ceará

| CAGECE - PMI DESSALINIZAÇÃO FORTALEZA - 1m³/s | | |
|---|---|---|
| PLANILHA ESTIMATIVA - ANTEPROJETO | | |
| ITEM | DESCRIÇÃO DOS SERVIÇOS | PREÇO TOTAL (R$) |
| | PMI DESSAL FORTALEZA | 484.486.896,89 |
| 1 | PROJETOS BÁSICOS E EXECUTIVOS | 8.098.601,03 |
| 2 | CONDUTAS ELEVATÓRIAS (INTERLIGAÇÃO COM REDE CAGECE) | 83.660.927,49 |
| 2.1 | SERVIÇOS PRELIMINARES (INCLUI MOBILIZAÇÃO/ADMINISTRAÇÃO LOCAL) | 10.434.732,75 |
| 2.2 | CANTEIRO DE OBRAS (INCLUI CONSTRUÇÃO DE CANTEIRO E MANUTENÇÃO) | 5.424.162,57 |
| 2.3 | TUBULAÇÕES E EQUIPAMENTOS - TRECHO 1 - PEAD DN 1000 | 11.278.180,80 |
| 2.4 | TUBULAÇÕES E EQUIPAMENTOS - TRECHO 2 - PEAD DN 710 | 7.163.628,05 |
| 2.5 | TUBULAÇÕES E EQUIPAMENTOS - TRECHO 3 - PEAD DN 800 | 49.360.223,32 |
| 3 | TORRE DE CAPTAÇÃO | 4.532.848,77 |
| 3.1 | SERVIÇOS PRELIMINARES (INCLUI MOBILIZAÇÃO/ADMINISTRAÇÃO LOCAL) | 565.366,26 |
| 3.2 | CANTEIRO DE OBRAS (INCLUI CONSTRUÇÃO DE CANTEIRO E MANUTENÇÃO) | 293.887,59 |
| 3.3 | OBRAS CIVIS | 3.673.594,92 |
| 4/5 | CONDUTA DE ADUÇÃO / EXPULSÃO | 92.727.330,42 |
| 4.1/5.1 | SERVIÇOS PRELIMINARES (INCLUI MOBILIZAÇÃO/ADMINISTRAÇÃO LOCAL) | 11.565.553,25 |
| 4.2/5.2 | CANTEIRO DE OBRAS (INCLUI CONSTRUÇÃO DE CANTEIRO E MANUTENÇÃO) | 6.011.983,49 |
| 4.3/5.3 | OBRAS OFF-SHORE | 38.601.606,20 |
| 4.4/5.4 | OBRAS DE INTERLIGAÇÃO EM VIAS ( CAPTAÇÃO ETA / EXPULSÃO ETA) | 36.548.187,48 |
| 6 | PLANTA/LAYOUT | 54.338.505,29 |
| 6.1 | SERVIÇOS PRELIMINARES (INCLUI MOBILIZAÇÃO/ADMINISTRAÇÃO LOCAL) | 6.777.450,33 |
| 6.2 | CANTEIRO DE OBRAS (INCLUI CONSTRUÇÃO DE CANTEIRO E MANUTENÇÃO) | 3.523.041,11 |
| 6.3 | CÂMARA DE CAPTAÇÃO | 12.289.434,70 |
| 6.4 | EDIFÍCIO DE ADMINISTRAÇÃO (2 PISOS) | 5.665.971,42 |
| 6.5 | EDIFÍCIO DO PROCESSO | 16.018.118,96 |
| 6.6 | DEPÓSITO DE ÁGUA E ESTAÇÃO ELEVATÓRIA | 4.056.317,54 |
| 6.7 | SUBESTAÇÃO ELÉTRICA | 130.805,88 |
| 6.8 | APOIO DOS FILTROS (SILOS) | 5.353.526,44 |
| 6.9 | APOIO DOS DEPÓSITOS DE REAGENTES | 523.838,92 |
| 7 | ACABAMENTOS FINAIS (INFRAESTRUTURA GERAL DA ÁREA) | 7.799.493,92 |
| 7.1 | SERVIÇOS PRELIMINARES (INCLUI MOBILIZAÇÃO/ADMINISTRAÇÃO LOCAL) | 972.803,40 |
| 7.2 | CANTEIRO DE OBRAS (INCLUI CONSTRUÇÃO DE CANTEIRO E MANUTENÇÃO) | 505.680,78 |
| 7.3 | SERVIÇOS INICIAIS | 966.724,13 |
| 7.4 | TERRAPLENAGEM | 1.701.374,64 |
| 7.5 | OBRAS DE DRENAGEM | 1.304.415,26 |
| 7.6 | PAVIMENTAÇÃO | 1.154.671,19 |
| 7.7 | PAISAGISMO | 1.012.982,92 |
| 7.8 | ILUMINAÇÃO EXTERIOR | 180.841,60 |
| 8 | EQUIPAMENTOS, MONTAGEM, TREINAMENTO E START-UP | 222.321.493,96 |
| 9 | FORNECIMENTO DE ENERGIA | 11.007.696,00 |



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# 12. Pilot Plant

Although simulation programs for commercial reverse osmosis membrane systems developed by different suppliers enable the elaboration of reverse osmosis unit projects, they do not consider possible interactions with organic contaminants and microorganisms with the membranes, and their effect on the reverse osmosis unit's performance. Likewise, it is important to include the influence of climatic changes on the quality of the water to be treated, which is a challenge to current computer models available, as well as on the pretreatment and reverse osmosis systems.

It is important to emphasize that membrane manufacturers declare to be exempt of liabilities regarding the use of simulations results obtained by their own simulation programs.

These conditions result in the need to perform preliminary testing in a pilot unit, whose operation shall enable the attainment of more trustworthy project parameters, for the pretreatment and reverse osmosis units alike. In addition, for a system as large as the one currently proposed, it is important to ensure availability of a pilot plant to allow evaluation of any alterations to be done in the production unit, especially regarding membrane chemical cleaning protocols or alterations in the chemicals to be used. This strategy reduces the risk of damage to the production unit, with a consequent reduction of potential operational and financial problems.

For pretreatment cases, it is important to inspect the quality and efficiency of the system chosen to obtain a water quality as required by membrane manufacturers, in terms of suspended matter and SDI.

A good pretreatment system choice will guarantee membrane durability, lower operational costs and, therefore, a lower cost of water produced per cubic meter.

The pilot study for an optimal pre-treatment selection shall be carried out on water samples collected in the same place and depth where the intake tower shall be built.

For the pretreatment system project, the pilot plant shall test:

- ✓ Different filter bed combination in first and second filtration stages;
- ✓ Different filtration speeds, setting the maximum speeds in each stage;
- ✓ Determination of the optimal chemical dosages needed to improve the quality of seawater to be treated;
- ✓ Simulation of filter washing cycles.

For the pretreatment system project, turbidity, suspended solids and SDI tests shall be carried out in filtered water to determine which procedure will provide better water quality for the treatment process (membrane entry).

The following is a description of the pilot plant designed for the present project.

The Pilot Plant's development costs are displayed within the amounts included for the execution of the Basic and Executive Projects.


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## 12.1. Initial Considerations

Whenever possible, it is recommended to carry out testing in the pilot plants with seawater, bearing the same characteristics as that used in the industrial size plant feed. These tests shall allow:

- ✓ To check the project in the process line: the results obtained in Pilot Plant reduce the risks in the expected process line, avoiding costs due to an incorrect project, or reducing them to optimize project criteria.

For example: if a higher filtration speed is used, without prejudice to filtered water quality, the size or number of filters to be installed could be reduced.

- ✓ Determine chemical reactant dosages: knowledge of this stage shall allow optimization of the chemical dosing and storage systems;
- ✓ Calculate operating costs more accurately
- ✓ Investigate product water quality

## 12.2. Sand Filter Pilot Plant Objectives

With the purpose of optimizing the pre-treatment line projected for the Fortaleza desalination plant, the Consortium plans to carry out several tests with seawater in the area where the intake tower and sampling shall be installed, at the same depth to be adopted for the project.

The tests allow:

- ✓ Confirmation of the type of layer or layers to be used in the first and second filtration steps;
- ✓ To determine the optimum height of the filter layers.
- ✓ To establish the need for chemicals to improve the quality of seawater entering the Reverse Osmosis membranes;
- ✓ To verify the filtration speeds to be used for the project;
- ✓ To optimize filter washing cycles in terms of flow and time, in the different washing phases.

### 12.2.1. Sand Filter Pilot Plant Description

The Pilot Plant consists of two independent filtration columns. Each column includes its complementary systems, which are:

- ✓ Air cleaning facility.
- ✓ Water cleaning facility.
- ✓ Coagulant and flocculant dosing system.

The Pilot Plant is designed to have the same layer and flow distribution parameters as the filtration system provided for the Fortaleza Desalination Plant, complying with kinematic and dynamic similarity laws.

In this way, the Pilot Plant test results can be considered representative of the projected filtration system.

Having a Pilot Plant shall allow the engineering team to improve and confirm project parameters.


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Figure 12.1 - Complete outlook of two columns with its complementary systems.

## 12.3. Reverse Osmosis Process Verification Plant

The previous plant shall be complemented with a Pilot Plant that will be used to verify the Reverse Osmosis structural project, optimize operating parameters, while simultaneously ensuring that product water quality complies with the regulations in force.

### 12.3.1. Proposal Description

The Pilot Plant includes a compact structure built with different steel types and the following elements:

#### 12.3.1.1. Feed and Cleaning Pump

The plant shall have a pump to drive the contents of the reservoir described below. To feed the osmosis membrane, it will use filtered water obtained through the previous pretreatment.

The flow shall be 10 $m^3/h$ at 6-bar pressure. The pump shall be constructed of stainless steel resistant to seawater and equipped with a 3KW motor.

#### 12.3.1.2. Agitation and Mixing Tank


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The deposit shall house 500 liters, be made of opaque polyethylene (PE) material and have a lid. The agitation will be carried out by recirculation with an open turbine pump and magnetic drag, a Pan World NH200, with aspiration in its lower part and the impulsion in its upper part.

A 6KW electric resistance element to head the fluid shall be installed in the deposit, at the bottom, so that it can also be used as a membrane-cleaning tank.

It shall also have a level switch, to prevent the pump and/or resistance from operating without fluid in the tank.

#### 12.3.1.3. Low-pressure piping and valves

Low-pressure transport shall be made in PVC PN10. The control and shutoff valves shall also be made of PN10 PVC.

#### 12.3.1.4. Flow meters

Two rotameters will be installed, one to measure permeate water, and the other to measure brine reject,

The rotameters will be Stübbe or similar brand, made of PVC, DN50, with a measuring capacity from 1000 to 10,000 L/h.

#### 12.3.1.5. Microfiltration

The microfiltration system for the driven product shall be installed from the mixing and agitation tank. It will be composed of three parallel housings, of the big, 20” type, with big 20” Twinpure cartridges and 5 microns pore size.

The housings shall be built in PP, and shall have a manual upper ventilation system.

#### 12.3.1.6. High-pressure manifolds and valves

The high-pressure manifolds shall be made of AISI 904L stainless steel, as well as the high-pressure valves.

The high-pressure flexible connections between the pressure vessel and the high-pressure manifolds, shall be Victaulic style77, in AISI 316 stainless steel.

#### 12.3.1.7. Work Pressure Control

The plant shall have four pressure gauges, two low-pressure 0-10 bar units and two other 0-100 bar units, Wika brand, 23X.50 type with spring tubular execution in stainless steel in the high-pressure line.

#### 12.3.1.8. Pressure Vessel

The pressure vessel shall be a Codeline brand, model 80S100-1, capable of accommodating an 8” osmosis membrane (the adapter membrane models shall still be defined), and for a maximum working pressure of 1000 psi.

#### 12.3.1.9. Feed, protection and maneuvers panel

The plant shall have a panel with the necessary protection and maneuver elements to start and stop the impulsion pump and the electrical resistance element. The device's manufacturer shall be mainly Telemecanique and Merlin Gerin.


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A Wika brand thermostat shall be installed as protection to avoid exceeding the fluid's temperature limit, when it is heated with the resistance heating element.

There shall also be a level transmitter in the tank, to prevent it from operating when empty.

The operation control shall be carried out from the maneuver panel, which has light switches and door selectors.

#### 12.3.1.10. High-pressure impeller pump

The plant shall have a high-pressure impeller pump powered from an external source, or from a feed pump that aspirates from the tank.

The valve sets involved in pump installation will also be included in the plant.

The pump to be installed is the CAT piston pump with stainless steel manifolds, Teflon gaskets and seals, aluminum oxide ceramic pistons, AISI 316 rods and valves. An AISI 316 pulsation damper and anti-cavitation valve will be included.

The pump provides a flow of 10 $m^3/h$ at a maximum pressure of 65 bar, with a 30 HP engine.

#### 12.3.1.11. Regulation Valve at the Feed Pump Drive

A DN50, PN10 diaphragm valve shall be installed in the feed pump drive to control flow and working pressure during cleaning. An additional pressure gauge will be installed before the valve to check current pump pressure.

#### 12.3.1.12. High Pressure Pump Bypass

A needle valve with bypass will be installed at the discharge pump outlet, to regulate its flow rate as described in the flow diagram.

The valve and the bypass circuit will be made of 904L stainless steel.

#### 12.3.1.13. Permeate Back Pressure Valve

A stainless steel pressure gauge for a 10-bar pressure and a PVC valve with a DN25 inclined seat shall be installed in the permeate manifold for the control of back pressure.

#### 12.3.1.14. Fluid Temperature Control Thermometer

In the pressure vessel inlet manifold, a needle thermometer will be included, inserted in the pipe, with a measurement range between 0-50ºC.

#### 12.3.1.15. Permeate Conductivity Sensor

An inductive conductivity sensor with a compact digital transmitter will be included in the permeated water line.

### 12.3.2. Flow diagram

The flow diagram of a BLUE GOLD-built Pilot Plant is presented below.


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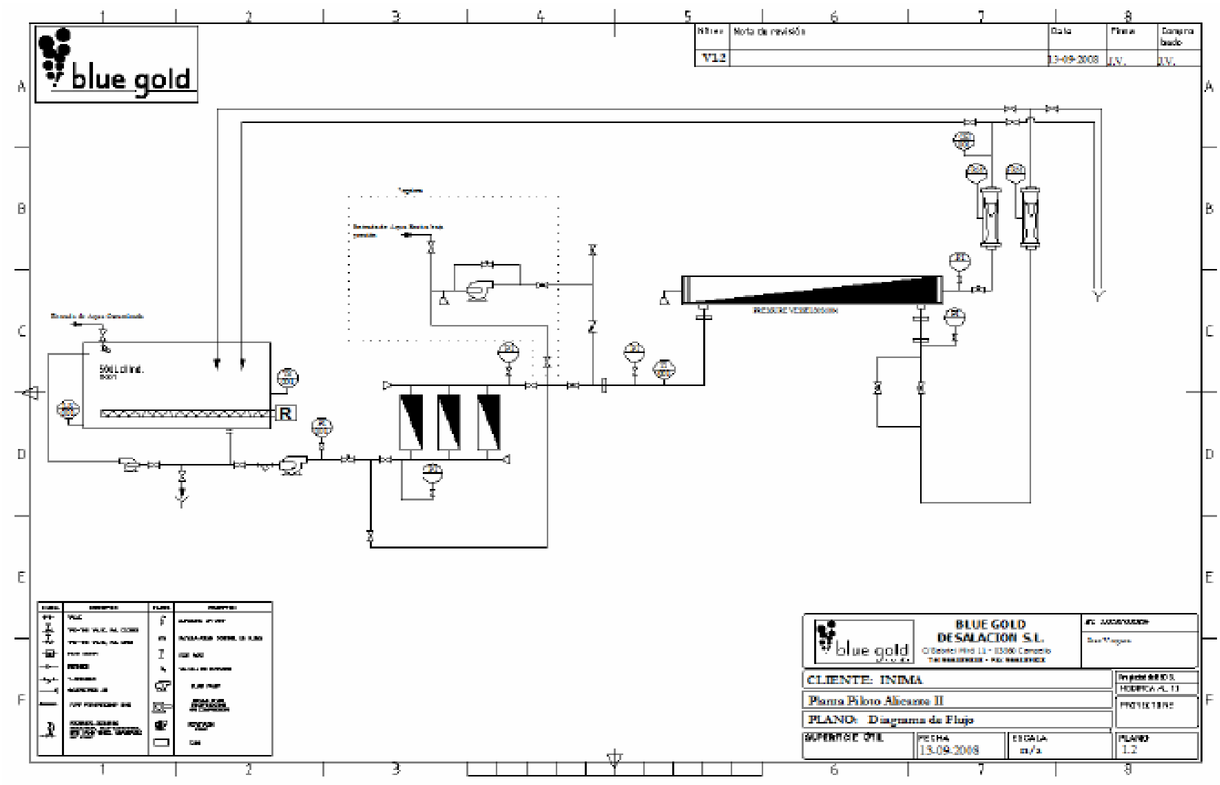


## 12.3.3. Photos


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# 13. Draft Descriptions

| DRAFT NR. | QTY | DESCRIPTION | FILE |
|---|---|---|---|
| | | **GENERAL LAYOUT** | |
| 01 | 01/01 | SEAWATER DESALINATION PROJECT GENERAL LAYOUT | GENERAL LAYOUT_DESAL R04 |
| | | | |
| | | **INTAKE** | |
| 02 | 01/02 | LAYOUT AND LONGITUDINAL PROFILE – INTAKE | PRAIA DO FUTURO Intake Main |
| 03 | 02/02 | LAYOUT AND LONGITUDINAL PROFILE – INTAKE | PRAIA DO FUTURO Intake Main |
| 04 | 01/01 | COLLECTION CHAMBER – PLANS, CUTS AND VIEWS | USI-CCAPT-101-0 |
| 05 | 01/01 | STRUCTURAL – COLLECTION CHAMBER – PLANS | USI-CCAPT-201-0 |
| 06 | 01/01 | STRUCTURAL – COLLECTION CHAMBER – SECTIONS | USI-CCAPT-202-0 |
| | | | |
| | | **DESALINATION PLANT** | |
| 07 | 01/01 | GENERAL IMPLEMENTATION PLAN | USI-PLT-101-0 |
| 08 | 01/01 | PLATFORM – DEMOLITION PLAN | USI-PLT-102-0 |
| 09 | 01/01 | GENERAL BULDING IMPLEMENTATION PLAN | USI-PLT-201-0 |
| 10 | 01/01 | LANDSCAPING PLATFORMT– AXIS PLAN | USI-PLT-301-0 |
| 11 | 01/02 | LANDSCAPING PLATFORMT– SECTIONAL PLAN | USI-PLT-302-0 |
| 12 | 02/02 | LANDSCAPING PLATFORMT– SECTIONAL PLAN | USI-PLT-303-0 |
| 13 | 01/01 | PLATFORM – DRAINAGE PLAN | USI-PLT-401-0 |
| 14 | 01/01 | PLATFORM – PAVING PLAN | USI-PLT-402-0 |
| 15 | 01/01 | FILTER SUPPORT STRUCTURES - SECTION PLANS | USI-ESTAP-201-0 |
| 16 | 01/01 | CHEMICAL RESERVOIR SUPPORT STRUCTURE - PLANS AND SECTIONS | USI-ESTAP-202-0 |
| 17 | 01/01 | FILTRATION MECHANICAL EQUIPMENT - PLANT | FIL-601 |
| 18 | 01/01 | - FLOOR 0 | USI-ADM-101-0 |
| 19 | 01/01 | PROCESS & ADMINISTRATIVE BUILDING PLAN - FLOOR 1 | USI-ADM-102-0 |
| 20 | 01/01 | PROCESS & ADMINISTRATIVE BUILDING PLAN - ROOF PLANT | USI-ADM-103-0 |
| 21 | 01/01 | PROCESS & ADMINISTRATIVE BUILDING PLAN – SECTION AND VIEWS | USI-ADM-104-0 |

| DRAFT NR. | QTY | DESCRIPTION | FILE |
|---|---|---|---|
| 22 | 01/01 | PROCESS & ADMINISTRATIVE BUILDING PLAN – SECTION AND VIEWS 2 | USI-ADM-105-0 |
| 23 | 01/01 | STRUCTURES - ADMINISTRATIVE BUILDING AND BRINE RESERVOIR - PLANS | USI-ADM-201-0 |
| 24 | 01/01 | STRUCTURES - ADMINISTRATIVE BUILDING AND BRINE RESERVOIR – PLANS AND SECTIONS | USI-ADM-202-0 |
| 25 | 01/01 | WATER AND SEWAGE NETWORK | USI-ADM-301-0 |
| 26 | 01/01 | WATER NETWORK - FLOOR 0 AND FLOOR 1 | USI-ADM-302-0 |
| 27 | 01/01 | SEWAGE NETWORK - FLOOR 0 AND FLOOR 1 | USI-ADM-303-0 |
| 28 | 01/01 | ACV EQUIPMENT IMPLEMENTATION - FLOOR 0 PLAN | USI-ADM-401-0 |
| 29 | 01/01 | ACV EQUIPMENT IMPLEMENTATION - FLOOR 1 PLAN | USI-ADM-402-0 |
| 30 | 01/01 | ACV EQUIPMENT IMPLEMENTATION – ROOF PLANT | USI-ADM-403-0 |
| 31 | 01/01 | GENERAL ELECTRIC INSTALLATIONS – FEED AND ENERGY SUPPLY - FLOOR 0 AND FLOOR 1 | USI-ADM-501-0 |
| 32 | 01/01 | GENERAL ELECTRIC INSTALLATIONS CABLE LAYOUT- TECHNICAL GUTTER AND FLOOR BOXES - FLOOR 0 AND FLOOR 1 | USI-ADM-502-0 |
| 33 | 01/01 | GENERAL ELECTRIC INSTALLATIONS - NORMAL LIGHTING - FLOOR 0 AND FLOOR 1 | USI-ADM-503-0 |
| 34 | 01/01 | GENERAL ELECTRIC INSTALLATIONS- SAFETY AND EMERGENCY LIGHTING - FLOOR 0 AND FLOOR 1 | USI-ADM-504-0 |
| 35 | 01/01 | GENERAL ELECTRIC INSTALLATIONS - GENERAL PURPOSE POWER OUTLETS - FLOOR 0 AND FLOOR 1 | USI-ADM-505-0 |
| 36 | 01/01 | GENERAL ELECTRIC INSTALLATIONS- GROUNDING SYSTEM - FLOOR 0 AND FLOOR 1 | USI-ADM-506-0 |
| 37 | 01/01 | GENERAL ELECTRIC INSTALLATIONS– TELECOMMUNICATION INSTALLATIONS FLOOR 0 AND FLOOR 1 | USI-ADM-507-0 |
| 38 | 01/01 | GENERAL ELECTRIC INSTALLATIONS - AUTOMATIC FIRE DETECTION SYSTEM - SADI - FLOOR 0 AND FLOOR 1 | USI-ADM-508-0 |
| 39 | 01/01 | GENERAL ELECTRIC INSTALLATIONS - AUTOMATIC INTRUSION AND THEFT DETECTION SYSTEM - SADIR - FLOOR 0 AND FLOOR 1 | USI-ADM-509-0 |
| 40 | 01/01 | STRUCTURES - PROCESS BUILDING - PLANS AND SECTIONS | USI-PRO-201 |
| 41 | 01/01 | RAINWATER NETWORKS - ROOF PLAN | USI-PRO-301 |
| 42 | 01/01 | RAINWATER NETWORKS - FLOOR 0 | USI-PRO-302 |
| 43 | 01/01 | GENERAL ELECTRIC INSTALLATIONS – POWER FEED AND DISTRIBUTION - FLOOR 0 (PROCESS) | USI-PRO-501 |
| 44 | 01/01 | GENERAL ELECTRIC INSTALLATIONS – CABLING PATHWAY – FLOOR 0 (PROCESS) | USI-PRO-502 |
| 45 | 01/01 | GENERAL ELECTRIC INSTALLATIONS – NORMAL LIGHTING – FLOOR 0 (PROCESS) | USI-PRO-503 |
| 46 | 01/01 | GENERAL ELECTRIC INSTALLATIONS – SAFETY LIGHTING – FLOOR 0 (PROCESS) | USI-PRO-504 |
| 47 | 01/01 | GENERAL ELECTRIC INSTALLATIONS – GENERAL PURPOSE POWER OUTLETS – FLOOR 0 | USI-PRO-505 |
| 48 | 01/01 | GENERAL ELECTRIC INSTALLATIONS – GROUNDING SYSTEM – FLOOR 0 (PROCESS) | USI-PRO-506 |
| 49 | 01/01 | REVERSE OSMOSIS - MECHANICAL EQUIPMENT – PLAN | USI-PRO-601 |

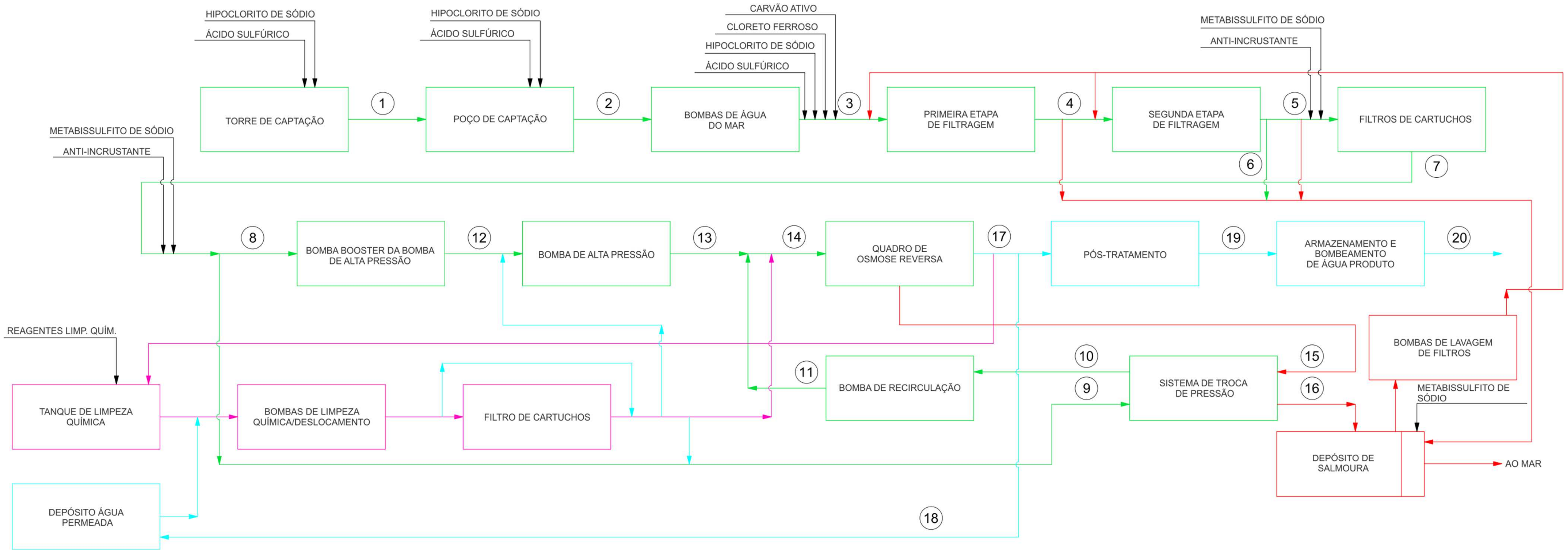
| DRAFT NR. | QTY | DESCRIPTION | FILE |
|---|---|---|---|
| 50 | 01/01 | REVERSE OSMOSIS - SECTIONS – HIGH PRESSURE SEAWATER INTAKE PIPING, MECHANICAL EQUIPMENT | USI-PRO-602 |
| 51 | 01/01 | REVERSE OSMOSIS - SECTIONS – HIGH-PRESSURE BRINE REJECT – MECANICAL EQUIPMENT | USI-PRO-603 |
| 52 | 01/01 | REVERSE OSMOSIS - SECTIONS – PERMEATE PIPING - MECHANICAL EQUIPMENT | USI-PRO-604 |
| 53 | 01/01 | REVERSE OSMOSIS - SECTIONS - MECHANICAL EQUIPMENT | USI-PRO-605 |
| 54 | 01/01 | MICROFILTERS - PLANS AND SECTIONS - MECHANICAL EQUIPMENT | USI-PRO-606 |
| 55 | 01/01 | REVERSE OSMOSIS - SECTIONS - MECHANICAL EQUIPMENT 2 | USI-PRO-607 |
| | | | |
| | | **MACROSYSTEM INTERCONNECTION** | |
| 56 | 01/01 | FINAL PRODUCT WATER STORAGE AND PUMPING STATION – PLANS, CUTS AND VIEWS | USI-DPF-101 |
| 57 | 01/01 | STRUCTURES – FINAL PRODUCT WATER STORAGE AND PUMPING STATION – PLANS | USI-DPF-201 |
| 58 | 01/01 | STRUCTURES – FINAL PRODUCT WATER STORAGE AND PUMPING STATION – SECTION PLANS | USI-DPF-202 |
| 59 | 01/01 | FINAL PRODUCT WATER STORAGE AND PUMPING STATION – RAINWATER NETWORKS | USI-DPF-301 |
| 60 | 01/09 | SECTION 1 – LAYOUT AND LONGITUDINAL PROFILE | ADT-01_09 |
| 61 | 02/09 | SECTIONS 1 AND 3 – LAYOUT AND LONGITUDINAL PROFILE | ADT-02_09 |
| 62 | 03/09 | SECTION 3 – LAYOUT AND LONGITUDINAL PROFILE | ADT-03_09 |
| 63 | 04/09 | SECTION 3 – LAYOUT AND LONGITUDINAL PROFILE | ADT-04_09 |
| 64 | 05/09 | SECTION 3 – LAYOUT AND LONGITUDINAL PROFILE | ADT-05_09 |
| 65 | 06/09 | SECTION 3 – LAYOUT AND LONGITUDINAL PROFILE | ADT-06_09 |
| 66 | 07/09 | SECTION 3 – LAYOUT AND LONGITUDINAL PROFILE | ADT-07_09 |
| 67 | 08/09 | SECTION 2 – LAYOUT AND LONGITUDINAL PROFILE | ADT-08_09 |
| 68 | 09/09 | SECTION 2 – LAYOUT AND LONGITUDINAL PROFILE | ADT-09_09 |
| 69 | 01/01 | AIR VENT VALVE DETAILS | Air Vent Valve Details |
| 70 | 01/01 | FLUSH VALVE DETAILS | Flush Valve Details |
| | | | |
| | | **FINAL OUTFALL** | |
| 71 | 01/02 | LAYOUT AND LONGITUDINAL PROFILE – MARINE OUTFALL | PRAIA DO FUTURO_Intake Main |
| 72 | 02/02 | LAYOUT AND LONGITUDINAL PROFILE – MARINE OUTFALL | PRAIA DO FUTURO_Intake Main |
| 73 | 01/01 | INTAKE AND DISCHARGE PIPES | CADES03 |
| | | | |
| | | **SUBSTATION** | |

| DRAFT NR. | QTY | DESCRIPTION | FILE |
|---|---|---|---|
| 74 | 01/01 | STRUCTURES – SUBSTATION – GENERAL PLAN | USI-SUBS-101-0 |
| 75 | 01/01 | STRUCTURES – NUCLEUS MT – SECTION PLANS | USI-SUBS-102 |
| 76 | 01/01 | STRUCTURES – TRANSFORMER NUCLEUS – PLANS AND SECTIONS | USI-SUBS-103 |
| 77 | 01/01 | TYPES OF METAL STRUCTURES | USI-SUBS-104 |

The aforementioned drafts can be found at Attachment – Project Portfolio, that complements this study.

# 14. ATTACHMENT

## 14.1. Plant Blocks and Flows Diagram




Source: GS Inima



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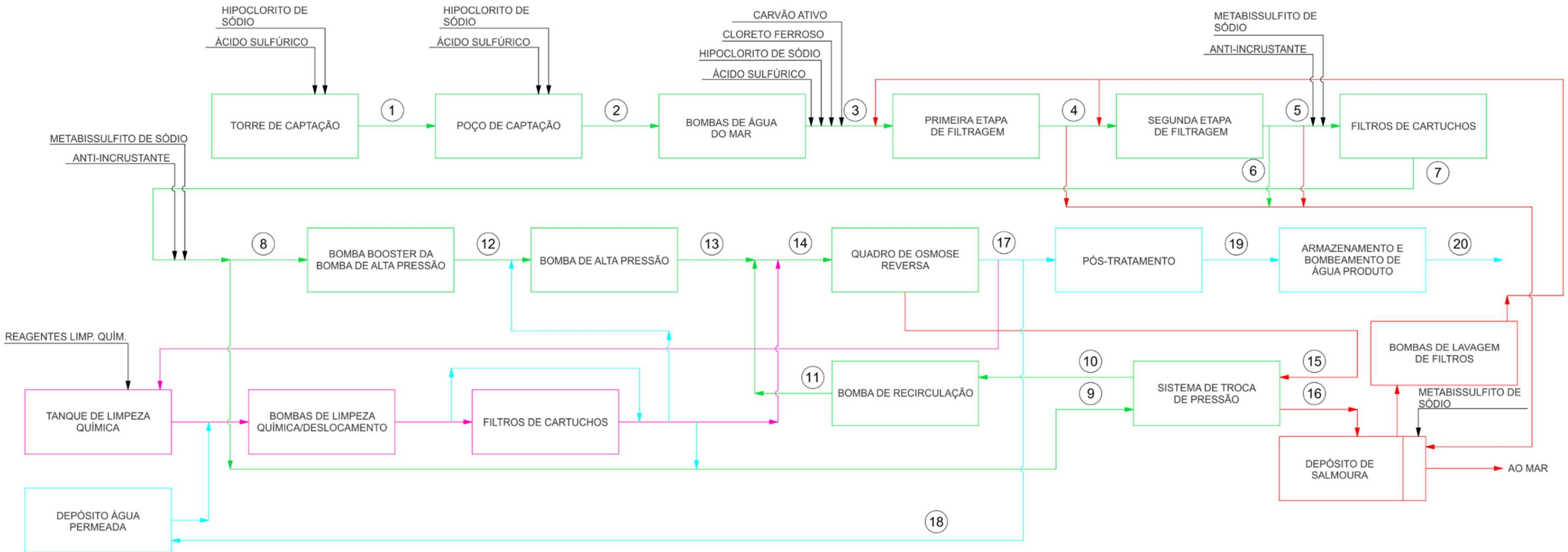
## 14.2. Process Mass Balance




| BALANÇO | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PONTO | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| DESCRIÇÃO | | Água do mar captada | Água do mar para BAM | Água do mar a partir de BAM | Água do mar para a Segunda etapa | Água do mar para filtros de cartuchos | Deslocamento após lavagem filtros | Água do mar para osmose reversa | Água do Mar para Booster BAP | Água do mar para SIP | Água do mar a partir de SIP | Água do mar a partir da bomba de recirculação | Água do mar para BAP | Água do mar a partir de BAP | Água do Mar para Quadros OI | Salmoura a partir de Quadros OI | Salmoura saída SIP | Água permeada a partir de Quadros OI | Água permeada para serviços | Água produto para depósito produto | Água producto |
| Fluxo nominal, uma linha de OI | m3/h | 2,006.0 | 2,006.0 | 2,006.0 | 2,006.0 | 2,006.0 | 0.0 | 2,006.0 | 915.4 | 1,090.6 | 1,090.6 | 1,090.6 | 1,061.3 | 915.4 | 2,006.0 | 1,103.3 | 1,103.3 | 902.7 | 2.7 | 225.0 | 225.0 |
| Fluxo máximo, uma linha de OI | m3/h | 3,152.3 | 3,152.3 | 3,152.3 | 3,152.3 | 2,006.0 | 1,146.3 | 2,006.0 | 915.4 | 1,090.6 | 1,090.6 | 1,090.6 | 1,061.3 | 915.4 | 2,006.0 | 1,103.3 | 1,103.3 | 902.7 | 2.7 | 225.0 | 225.0 |
| Fluxo nominal, todas as linhas OI | m3/h | 8,024.0 | 8,024.0 | 8,024.0 | 8,024.0 | 8,024.0 | 0.0 | 8,024.0 | 3,661.6 | 4,362.4 | 4,362.4 | 4,362.4 | 8,490.8 | 3,661.6 | 8,024.0 | 4,413.2 | 4,413.2 | 3,610.8 | 10.8 | 900.0 | 900.0 |
| Fluxo máximo, todas as linhas OI | m3/h | 9,170.3 | 9,170.3 | 9,170.3 | 9,170.3 | 8,024.0 | 1,146.3 | 8,024.0 | 3,661.6 | 4,362.4 | 4,362.4 | 4,362.4 | 8,490.8 | 3,661.6 | 8,024.0 | 4,413.2 | 4,413.2 | 3,610.8 | 10.8 | 900.0 | 900.0 |
| Pressão | barg | 0.1 | 0.1 | 7.1 | 4.5 | 4.0 | 0.1 | 3.3 | 2.5 | 2.3 | 64.9 | 64.4 | 10.9 | 64.6 | 63.0 | 58.9 | 1.5 | 1.3 | 1.3 | 0.3 | 4.2 |
| TDS (Total de Sais Dissolvidos) = | mg/L | 39,052.0 | 39,052.0 | 39,052.0 | 39,055.8 | 39,055.8 | 39,055.8 | 39,055.8 | 39,055.8 | 39,055.8 | 41,073.4 | 41,073.4 | 39,055.8 | 39,055.8 | 40,152.7 | 72,681.7 | 70,687.3 | 391.7 | 391.7 | 474.0 | 474.0 |

Source: GS Inima



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## 14.3. Process Calculation Memory

Planta de Fortaleza

CALCULOS DE DESENHO DA PLANTA DESSALINIZADORA



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## Planta de Fortaleza

**DADOS DO DESENHO**

| | |
|---|---|
| Produção final da planta | 86.400 m3/d |
| Fator de conversão da planta | 45,0% |
| Horas de funcionamento diárias | 24 horas |
| Dias de funcionamento ao ano | 350 dias |
| Tipo de agua bruta a tratar | Do Mar |
| Temperatura maxima da agua bruta | 30 ºC |
| Temperatura minima da agua bruta | 22 ºC |
| Curso da maré | 3,625 m |
| Cota da instalação | 5 m |
| Cota maxima de bombeamento do produto | 40,5 m |
| Cota de referência zero | Nivel médio do mar |
| Linha de pré tratamento químico | Acido Sulfurico |
| | Hipoclorito De Sódio |
| | Metabisulfito Sodico |
| | Cloreto Ferrico |
| | Dispersante |
| | Hidróxido De Sódico |
| | Dispersante |
| Linha de pós tratamento do produto | Anhidrido Carbônico |
| | Hidroxido De Calcio |
| | Fluorosilicato De Sodio |
| | Hipoclorito De Sódio |
| QUALIDADE FINAL DO PRODUTO | |
| TDS (max.) | 474 mg/L |
| Alcalinidade como CO3Ca | 50,5 mg/L |
| Dureza como CO3Ca | 65,1 mg/L |
| pH | 8,6 |
| LSI | 0,1 |
| Cloretos | 227 mg/L |

Source: GS Inima



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## 1.- CAPTAÇÃO DE ÁGUA DO MAR



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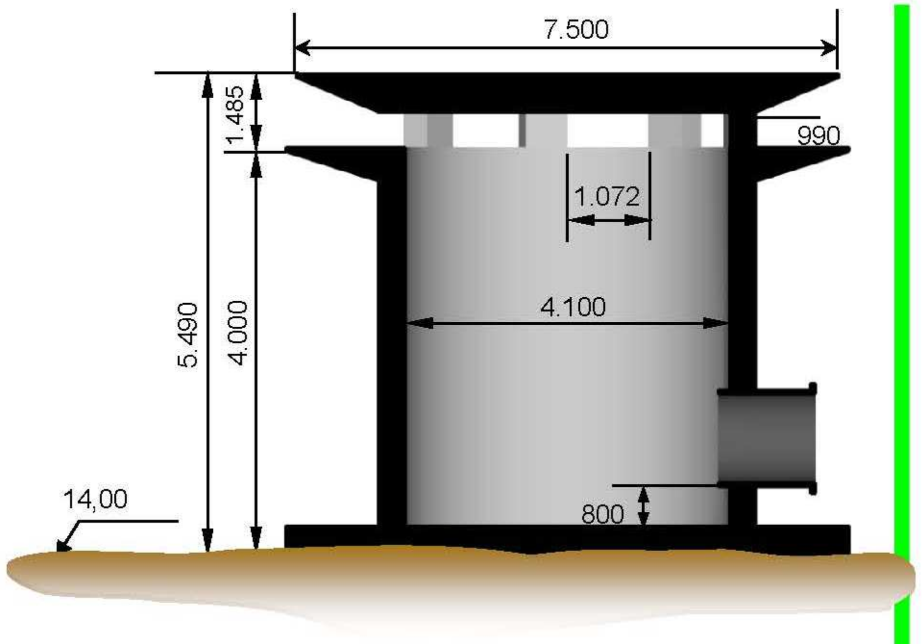
## Planta de Fortaleza

### 1.- CAPTAÇÃO DE ÁGUA DO MAR

1.1.- TORRE DE CAPTAÇÃO DE ÁGUA DO MAR

| | |
|---|---|
| Produção nominal do desenho | 86.400 m3/d |
| Vazão total de agua do mar para o desenho | 9.170 m3/h |
| Número de torres a instalar: | 1 Uds. |
| Velocidade máxima nas janelas da torre | 0,3 m/seg. |
| Área minima janelas de entrada da torre | 8,49 m2 |
| Numero de janelas de entrada | 8 Uds. |
| Altura das janelas de entrada | 990 mm. |
| Largura das janelas de entrada | 1.072 mm. |
| Velocidade maxima no interior da torre | 0,2 m/seg. |
| Diametro interior da torre | 4,1 m. |
| Altura do fundo marinho na borda inferior da janelas | 4 m. |
| Altra do fundo torre a geratriz inferior da tubulação | 0,8 m. |
| Diametro da tampa da torre | 7,5 m. |
| Altura periférica exterior da captação | 1.485 mm. |
| Velocidade periférica exterior da captação | 0,08 m/seg. |
| Altura total da torre | 5,49 m. |
| Batimetria do fundo marinho: | 14,00 m. |




Source: GS Inima



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## MAIN PIPELINE SIZING

### 1.0 Discharge Flow

| | | | |
|---|---|---|---|
| 1.2 | **Maximum discharge flow** | 1.80 | $m^3/s$ |
| | | 1,797.22 | l/s |
| | | 6,470.00 | $m^3/h$ |

### 2.0 Discharge

| | | | |
|---|---|---|---|
| 2.1 | **Intake flow** | 1,800.00 | l/s |
| | | 6,480.00 | $m^3/h$ |
| 2.2 | **Intake type** | Open | |
| 2.3 | **Number of pipes** | 1.00 | un |
| 2.4 | **Length** | 1,760.00 | m |
| 2.5 | **Material** | PEAD | |
| 2.6 | **Diameter Nominal** | 1,200.00 | mm |
| 2.7 | **External diameter** | 1,200.00 | mm |
| 2.8 | **Thickness** | 67.90 | mm |
| 2.9 | **Internal diameter** | 1,064.20 | mm |
| 2.10 | **Velocity** | 2.02 | m/s |

### 3.0 Head Losses

**3.1 Head Loss Throughout the Piping System**

| | | |
|---|---|---|
| Temperature | 30.00 | ºC |
| ν (Kinematic Viscosity) | 1.40E-06 | $m^2/s$ |
| e (Roughness Coefficient) | 0.0015 | mm* |

* Piping subject to corrosion and incrustation (Azevedo Netto)

| | | |
|---|---|---|
| g (Gravity) | 9.81 | $m/s^2$ |
| Reynolds number (Re) | 1.54E+06 | |
| Friction factor | 0.010875745 | |
| Distributed head loss | 0.0021265 | m/m |
| Head loss by length (J) | 3.74 | m |

**3.2 Local Head Loss**

| Part | Quant. | K | Total K |
|---|---|---|---|
| 90 curve | 2.00 | 0.40 | 0.80 |
| 45 curve | 1.00 | 0.20 | 0.20 |
| Normal piping entrance | 1.00 | 0.50 | 0.50 |
| Piping exit | 1.00 | 1.00 | 1.00 |
| Open port | 0.00 | 1.00 | 0.00 |
| | | | **2.50** |

| | | |
|---|---|---|
| Local head loss | 0.52 | m |

**3.3 Total head losses** **4.26** **m**

**Minimum Water Level Rate in the Collection Chamber**

| | | |
|---|---|---|
| Pipeline head losses | 4.26 | m |
| Load Chamber Height | 5 | m |
| Outlet rate | -12.17 | m |
| Geometric height | 17.17 | |
| **Outlet Pressure** | **12.91** | **m** |



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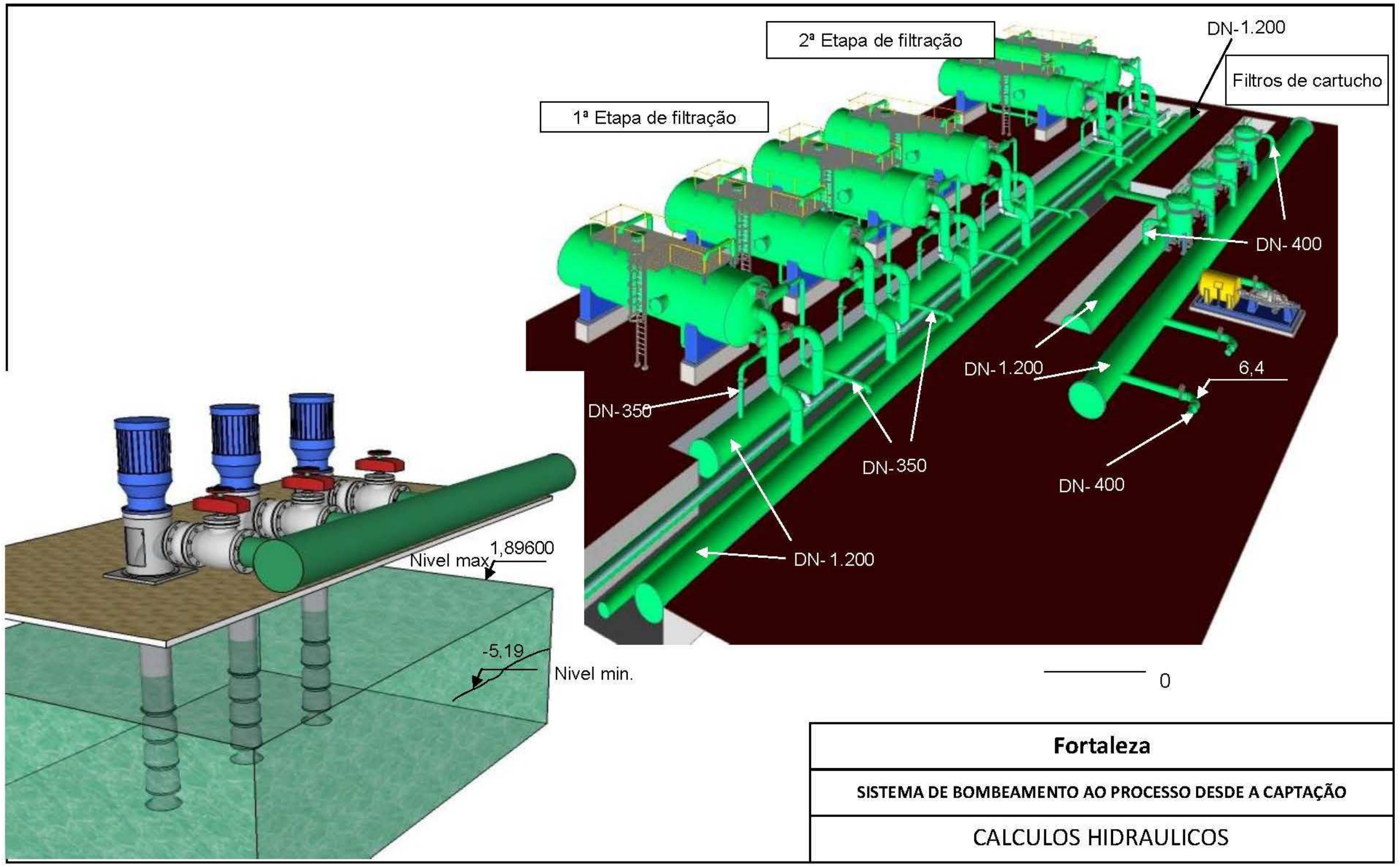
## Planta de Fortaleza




Source: GS Inima



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## Planta de Fortaleza

### FOLHA DE ANÁLISE

| | | | |
|---|---|---|---|
| CLIENTE | | CONTRATO | |
| LABORATÓRIO | | REFERÊNCIA | |
| TIPO DE ÁGUA | DO MAR | DATA | November-17 |
| LUGAR DE AMOSTRAGEM | Costa de Fortaleza | | |

| ANÁLISE FISICO-QUIMICO | | | | | |
|---|---|---|---|---|---|
| TURBIDEZ | 1 | U.N.F. | PH | 7,90 | |
| COR | 1 | Pt-Co | CONDUTIBILIDADE | 58.846,93 | µmhos/cm. |
| ODOR | 0 | TON | T.D.S. | 39.051,86 | mg/L |
| ASPECTO | | | ALCALINIDADE | 133,85 | ppm CO3Ca |
| TEMPERATURA | 27 | ºC | DUREZAE | 6.403,60 | ppm CO3Ca |
| **COMPOSIÇÃO IONICA** | | | | | |
| **ELEMENTO** | **mg/L** | **meq/L** | **ELEMENTO** | **mg/L** | **meq/L** |
| Ca++ | 504,55 | 25,18 | SO4= | 4.159,73 | 86,61 |
| Mg++ | 1.249,42 | 102,78 | Cl- | 20.425,10 | 576,12 |
| Na+ | 12.110,61 | 526,75 | CO3H- | 142,78 | 2,34 |
| K+ | 420,00 | 10,74 | F- | 0,30 | 0,02 |
| Ba++ | 0,02 | 0,00 | Br- | 0,00 | 0,00 |
| Sr++ | 5,10 | 0,12 | I- | 0,00 | 0,00 |
| Fe++ | 0,00 | 0,00 | NO2- | 0,00 | 0,00 |
| NH4+ | 0,30 | 0,02 | NO3- | 10,70 | 0,17 |
| Ag+ | 0,00 | 0,00 | CO3= | 10,04 | 0,33 |
| Mn++ | 0,00 | 0,00 | PO4≡ | 0,00 | 0,00 |
| Zn++ | 0,00 | 0,00 | S= | 0,00 | 0,00 |
| Cu++ | 0,00 | 0,00 | SiO2 (coloidal) | 0,20 | 0,00 |
| Al+++ | 0,00 | 0,00 | SiO2 (soluble) | 8,20 | 0,14 |
| Fe+++ | 0,00 | 0,00 | CO2 | 1,23 | 0,03 |
| H+ | | 0,00 | OH- | | 0,00 |
| **TOTAL** | **14.290,00** | **665,59** | **TOTAL** | **24.756,85** | **665,59** |

| OUTRAS DETERMINAÇÕES | | | |
|---|---|---|---|
| **SUBSTÂNCIAS TOXICAS** | **mg/L** | **Matéria orgânica e outros** | **mg/L** |
| Arsênio | 0,00 | DBO5 | 2,00 |
| Cádmo | 0,00 | DQO | 5,00 |
| Bário | 5,00 | Nitrogêno proteico | 0,00 |
| Mercurio | 0,00 | Compostos fenólicose | 0,00 |
| Chumbo | 0,00 | Detergentes | 0,00 |
| Selênio | 0,00 | Oleos e graxas | 0,00 |
| Cromo total | 0,00 | Hidrocarbonetos | 0,00 |
| Cromo | 0,00 | Sólidos em suspensão | 10,00 |

Observações

Estas analises da agua do mar pude diferir ligeramente do entregue, devido ao equilibrio desde o ponto de vista químico

DATA REALIZADO POR ASSINATURA

## Planta de Fortaleza

### PROPRIEDADES FISICO-QUIMICO

| | | |
|---|---|---|
| TIPO DE ÁGUA | DO MAR | |
| TEMPERATURA | 27 | ºC |
| SOLIDOS TOTAIS DISSOLVIDOS | 39.052 | mg/L |
| CONDUTIBILIDADE A 25ºC | 58.847 | microS/cm. |
| DENSIDADE | 1,025 | Kg/l |
| VISCOSIDADE CINEMATICA | 0,009 | stokes |
| VISCOSIDADE DINAMICA | 0,926 | cp. |
| PRESSÃO DO VAPOR | 0,035 | bars |
| PONTO DE EBULIÇÃO | 0,374 | ºC |
| CALOR ESPECIFICO | 0,951 | Kcal/KgxºC |
| CONDUTIBILIDADE TÉRMICA | 581,7 | mW/mxºC |
| ENTALPIA | 25,56 | Kcal/Kg |
| INDICE DE LANGELIER: | 0,85 | incrustante |
| INDICE DE STIFF & DAVIS: | 0,08 | |
| INDICE DE SAL | 65,85 | |
| MAXIMO OXIGÊNIO DISSOLVIDO | 6,1 | mg/L |
| MAXIMO NITROGÊNIO DISSOLVIDO | 8,4 | mg/L |
| CO2 DISSOLVIDO | 1,23 | mg/L |
| FORÇA IONICA DA ÁGUA | 0,77352 | |
| PRESSÃO OSMÓTICA DA ÁGUA | 32,92 | bars |

Source: GS Inima



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2.- PRÉ TRATAMENTO DA ÁGUA DO MAR



2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

CÁLCULO DAS DOSAGENS

2.1.1.- DOSAGEM DE ACIDO SULFÚRICO

| SO4H2 | + | 2CO3H - | --------- | SO4= | + | 2CO2 | + | 2H2O |
|---|---|---|---|---|---|---|---|---|
| 98 | | 122 | | 96 | | 88 | | 36 |
| 7,03 | | Y3 | | Y1 | | Y5 | | |

Y1 = 6,89 mg/L

Y3 = 8,75 mg/L

Y5 = 6,31 mg/L

| COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM | | | | | |
|---|---|---|---|---|---|
| | | | $CO3^{=}$ = | 4,09 | mg/L |
| $Ca^{++}$ = | 504,55 | mg/L | $SO4^{=}$ = | 4.166,62 | mg/L |
| $Mg^{++}$ = | 1.249,42 | mg/L | $Cl^{-}$ = | 20.425,10 | mg/L |
| $Na^{+}$ = | 12.110,61 | mg/L | $CO3H^{-}$ = | 146,16 | mg/L |
| $K^{+}$ = | 420,00 | mg/L | $PO4^{=}$ = | 0,00 | mg/L |
| $Fe^{++}$ = | 0,00 | mg/L | CO2 = | 3,15 | mg/L |
| pH(inicial)= | 7,90 | | pH(final)= | 7,50 | |

Source: GS Inima



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Companhia de Água e Esgoto do Ceará

## Planta de Fortaleza

### 2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

### CÁLCULO DAS DOSAGENS

2.1.2.- DOSAGEM DE HIPLOCLORITO SODICO (FORA LINHA)

| ClONa | + | H2O | -------- | ClOH | + | NaOH |
|---|---|---|---|---|---|---|
| 74,4 | | 18 | | 52,5 | | 40 |
| 103,33 | | | | Y2 | | X3 |

A quantidade do produto a dosar dependerá a quantidade de materia organica a eliminar, portanto é um dado que deverá ser ajustado na operação. Não obstante a experiencia nos diz que uma dose do produto de 10 mg/L como cloro livre, é suficiente em geral

Y2 = 0,00 mg/L

X3(Na+) = 0,00 mg/L

| COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM | | | |
|---|---|---|---|
| | | $CO3^{=}$ = | 4,09 mg/L |
| $Ca^{++}$ = | 504,55 mg/L | $SO4^{=}$ = | 4.166,62 mg/L |
| $Mg^{++}$ = | 1.249,42 mg/L | $Cl^{-}$ = | 20.425,10 mg/L |
| $Na^{+}$ = | 12.110,61 mg/L | $CO3H^{-}$ = | 146,16 mg/L |
| $K^{+}$ = | 420,00 mg/L | $PO4^{=}$ = | 0,00 mg/L |
| $Fe^{+++}$ = | 0,00 mg/L | CO2 = | 3,15 mg/L |
| pH(inicial)= | 7,50 | pH(final)= | 7,50 |

## Planta de Fortaleza

### 2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

### CÁLCULO DAS DOSAGENS

2.1.3.- DOSAGEM METABISULFITO DE SODIO (FORA DE LINHA)

| S2O5Na2 + | 2ClOH + | 6CO3H - ----- | 2SO4= + | 2NaOH + | 2Cl - + | 6CO2 + | 3H2O |
|---|---|---|---|---|---|---|---|
| 190 | 105 | 366 | 192 | 80 | 71 | 264 | 54 |
| A | | Y3 | Y1 | X3 | Y2 | Y5 | |

Por segurança suponharemos que queixam 1 ppm de cloro residual

A = 0 mg/L

Y1 = 0,00 mg/L

Y2 = 0,00 mg/L

X3(Na+) = 0,00 mg/L

Y3 = 0,00 mg/L

Y5 = 0,00 mg/L

| COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM | | | |
|---|---|---|---|
| | | $CO3^{=}$ = | 4,09 mg/L |
| $Ca^{++}$ = | 504,55 mg/L | $SO4^{=}$ = | 4.166,62 mg/L |
| $Mg^{++}$ = | 1.249,42 mg/L | $Cl^{-}$ = | 20.425,10 mg/L |
| $Na^{+}$ = | 12.110,61 mg/L | $CO3H^{-}$ = | 146,16 mg/L |
| $K^{+}$ = | 420,00 mg/L | $PO4^{=}$ = | 0,00 mg/L |
| $Fe^{+++}$ = | 0,00 mg/L | CO2 = | 3,15 mg/L |
| pH(inicial)= | 7,50 | pH(final)= | 7,50 |

Source: GS Inima



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## Planta de Fortaleza

**2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR**

**CÁLCULO DAS DOSAGENS**

2.1.4.- DOSAGEM CLORETO FERRICO

| | | | | | | |
|---|---|---|---|---|---|---|
| Cl3Fe + | 3(CO3H)- | ------------ | Fe(OH)3 + | 3CO2 + | 3Cl- | |
| 162,4 | 183 | | 106,9 | 132 | 106,5 | |
| 5,00 | Y3 | | X5(precipita) | Y5 | Y2 | |

A quantidade do produto a dosar dependerá a quantidade de sólidos em suspesão e coloides a eliminar, devendo ser ajustado na operação. Não obstante a experiencia nos diz que uma dose do produto de 5 mg/L é suficiente na maioria dos casos

Y2 = 3,28 mg/L

Y3 = 5,64 mg/L

X5 = 3,29 mg/L    Y5 = 4,07 mg/L

COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM

| | | | | | |
|---|---|---|---|---|---|
| | | | $CO3^{=}$ = | 2,17 | mg/L |
| $Ca^{++}$ = | 504,55 | mg/L | $SO4^{=}$ = | 4.166,62 | mg/L |
| $Mg^{++}$ = | 1.249,42 | mg/L | $Cl^{-}$ = | 20.428,38 | mg/L |
| $Na^{+}$ = | 12.110,61 | mg/L | $CO3H^{-}$ = | 144,43 | mg/L |
| $K^{+}$ = | 420,00 | mg/L | $PO4^{=}$ = | 0,00 | mg/L |
| $Fe^{+++}$ = | 0,00 | mg/L | CO2 = | 5,81 | mg/L |
| pH(inicial)= | 7,50 | | pH(final)= | 7,23 | |

## Planta de Fortaleza

**2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR**

**CÁLCULO DAS DOSAGENS**

2.1.5.- DOSAGEM DE DISPERSANTE

Ver nas folhas anexas o comportamento do dispersante
para uma dose de dispersante Permatrit-191, em mg/L., de:
1,00

COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM

| | | | | | |
|---|---|---|---|---|---|
| | | | $CO3^{=}$ = | 2,17 | mg/L |
| $Ca^{++}$ = | 504,55 | mg/L | $SO4^{=}$ = | 4.166,62 | mg/L |
| $Mg^{++}$ = | 1.249,42 | mg/L | $Cl^{-}$ = | 20.428,38 | mg/L |
| $Na^{+}$ = | 12.110,61 | mg/L | $CO3H^{-}$ = | 144,43 | mg/L |
| $K^{+}$ = | 420,00 | mg/L | $PO4^{=}$ = | 0,00 | mg/L |
| $Fe^{+++}$ = | 0,00 | mg/L | CO2 = | 5,81 | mg/L |
| pH(inicial)= | 7,23 | | pH(final)= | 7,23 | |

Source: GS Inima



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## Planta de Fortaleza

### 2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

### DESENHO DOS EQUIPAMENTOS DE DOSAGEM

2.1.1.- DOSAGEM DE ACIDO SULFÚRICO

| | | |
|---|---|---|
| Vazão de agua do mar a tratar | m3/h | 9.027 |
| Dose do produto puro | mg/L | 7,03 |
| Riqueza de produto comercial | % | 96,00 |
| Densidade do produto | Kg/l | 1,84 |
| Quantidade do produto a dosar | gr/h | 63.483,6 |
| Quantidade do produto comercial | kg/h | 66,1 |
| Vazão do produto a dosar | l/h | 36 |
| Número de bombas dosadoras em operação | Uds. | 2 |
| Número de bombas dosadoras em reserva | Uds. | 1 |
| Vazão da dosagem por bomba | l/h | 18 |
| Vazão nominal da bomba dosadora | l/h | 40 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 0,37 |

| | | |
|---|---|---|
| Tempo de reserva do produto armazenado | dias | 30 |
| Numero de tanques de armazenamento | Uds. | 2 |
| Volume de cada tanque de armazenamento | m3 | 12 |
| Tempo real de reserva no armazenamento | dias | 28,6 |
| Consumo anual de produto por este conceito | Ton | 555,5 |

Source: GS Inima



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## Planta de Fortaleza

### 2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

### DESENHO DOS EQUIPAMENTOS DE DOSAGEM

2.1.2.- DOSAGEM DE HIPLOCLORITO SODICO (FORA LINHA)

| | | |
|---|---|---|
| Vazão de agua do mar a tratar | m3/h | 8.024 |
| Dose do produto puro | mg/L | 10,00 |
| Riqueza de produto comercial | gr/l | 120,00 |
| Densidade do produto | Kg/l | 1,24 |
| Quantidade do produto a dosar | gr/h | 80.240,0 |
| Quantidade do produto comercial | l/h | 668,7 |
| Vazão do produto a dosar | l/h | 669 |
| Número de bombas dosadoras em operação | Uds. | 2 |
| Número de bombas dosadoras em reserva | Uds. | 1 |
| Vazão da dosagem por bomba | l/h | 334 |
| Vazão nominal da bomba dosadora | l/h | 500 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 0,37 |

| | | |
|---|---|---|
| Horas ao ano de desinfecção da planta: | horas | 31 |
| Numero de tanques de armazenamento | Uds. | 2 |
| Volume de cada tanque de armazenamento | m3 | 12 |
| Tempo real de reserva no armazenamento | dias | 47,5 |
| Consumo anual de produto por este conceito | Ton | 26,1 |

Source: GS Inima



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## Planta de Fortaleza

### 2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

### DESENHO DOS EQUIPAMENTOS DE DOSAGEM

2.1.3.- DOSAGEM METABISULFITO DE SODIO (FORA DE LINHA)

| | | |
|---|---|---|
| Vazão de agua do mar a tratar | m3/h | 8.024 |
| Dose do produto puro | mg/L | 1,81 |
| Riqueza de produto comercial | % | 61,00 |
| Diluição do produto | % | 10 |
| Quantidade do produto a dosar | gr/h | 14.519,6 |
| Quantidade do produto comercial | kg/h | 23,8 |
| Vazão do produto a dosar | l/h | 238 |
| Número de bombas dosadoras em operação | Uds. | 2 |
| Número de bombas dosadoras em reserva | Uds. | 1 |
| Vazão da dosagem por bomba | l/h | 119 |
| Vazão nominal da bomba dosadora | l/h | 150 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 0,37 |
| Tempo minimo da dissolução disponível | horas | 8 |
| Numero de tanques de dissolução | Uds. | 2 |
| Volume de cada tanque | litros | 1000 |
| Tempo real de dissolução disponivel | horas | 8,4 |
| Horas ao ano de desinfecção da planta: | horas | 31 |
| Quantidade de produto a armazenar | Ton | 0,1 |
| Consumo anual de produto por este conceito | Ton | 0,7 |

Source: GS Inima



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## Planta de Fortaleza

### 2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

### DESENHO DOS EQUIPAMENTOS DE DOSAGEM

2.1.4.- DOSAGEM CLORETO FERRICO

| | | |
|---|---|---|
| Vazão de agua do mar a tratar | m3/h | 9.027 |
| Dose do produto puro | mg/L | 5,00 |
| Riqueza de produto comercial | % | 40 |
| Densidade do produto | Kg/l | 1,417 |
| Quantidade do produto a dosar | gr/h | 45.135,0 |
| Quantidade do produto comercial | kg/h | 112,8 |
| Vazão do produto a dosar | l/h | 80 |
| Número de bombas dosadoras em operação | Uds. | 2 |
| Número de bombas dosadoras em reserva | Uds. | 1 |
| Vazão da dosagem por bomba | l/h | 40 |
| Vazão nominal da bomba dosadora | l/h | 60 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 0,37 |

| | | |
|---|---|---|
| Tempo de reserva do produto armazenado | dias | 30 |
| Numero de tanques de armazenamento | Uds. | 2 |
| Volume de cada tanque de armazenamento | m3 | 30 |
| Tempo real de reserva no armazenamento | dias | 32,3 |
| Consumo anual de produto por este conceito | Ton | 947,8 |

Source: GS Inima


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## Planta de Fortaleza

### 2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

### DESENHO DOS EQUIPAMENTOS DE DOSAGEM

2.1.5.- DOSAGEM DE DISPERSANTE

| | | |
|---|---|---|
| Vazão de agua do mar a tratar | m3/h | 8.024 |
| Dose do produto puro | mg/L | 1,00 |
| Riqueza de produto comercial | % | 95 |
| Diluição do produto | % | 100 |
| Quantidade do produto a dosar | gr/h | 8.024,0 |
| Quantidade do produto comercial | kg/h | 8,4 |
| Vazão do produto a dosar | l/h | 8 |
| Número de bombas dosadoras em operação | Uds. | 2 |
| Número de bombas dosadoras em reserva | Uds. | 1 |
| Vazão da dosagem por bomba | l/h | 4 |
| Vazão nominal da bomba dosadora | l/h | 10 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 0,37 |
| Tempo minimo da dissolução disponível | horas | 24 |
| Numero de tanques de dissolução | Uds. | 2 |
| Volume de cada tanque | litros | 500 |
| Tempo real de dissolução disponivel | horas | 118,4 |
| Tempo de reserva do produto armazenado | dias | 30 |
| Quantidade de produto a armazenar | Ton | 5,9 |
| Consumo anual de produto por este conceito | Ton | 70,9 |

Source: GS Inima



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**Planta de Fortaleza**

## 2.1.- PRÉ TRATAMENTO QUIMICO DA ÁGUA DO MAR

### DESENHO DOS EQUIPAMENTOS DE DOSAGEM

2.1.6.- BOMBAS DE TRANSFERÊNCIA

| | | ACIDO SULFURICO | HIPOCLORITO SÓDICO | CLORURO FÉRRICO |
|---|---|---|---|---|
| Volume da cisterna do caminhão | m3 | 30 | 45 | 30 |
| Tempo de transferência: | minutos | 30 | 30 | 30 |
| Vazão de transferência: | m3/h | 60 | 90 | 60 |
| Pressão de transferência: | bars | 1,5 | 1,5 | 1,5 |
| Número de bombas de transferência: | Uds. | 1 | 1 | 1 |
| Potência do motor | Kw | 6 | 9 | 6 |

Source: GS Inima



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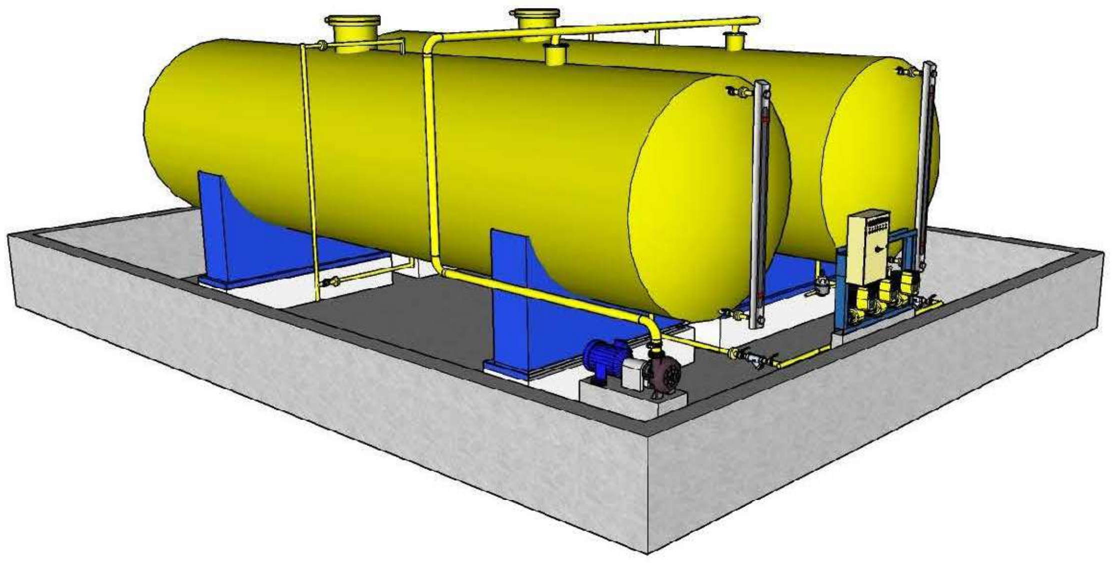
## Planta de Fortaleza

**2.1- PRETRATAMIENTO QUÍMICO DEL AGUA DE MAR**

**DESENHO DOS EQUIPAMENTOS DE DOSAGEM**



| **PRODUTOS QUIMICOS** | |
|---|---|
| ACIDO SULFURICO | 2 x 12 m3 |
| HIPOCLORITO SÓDICO | #N/A |
| CLORURO FÉRRICO | #N/A |

**Fortaleza**

**QUIPAMENTOS DE DOSAGEM (LÍQUIDO)**

Planta de Fortaleza

Source: GS Inima



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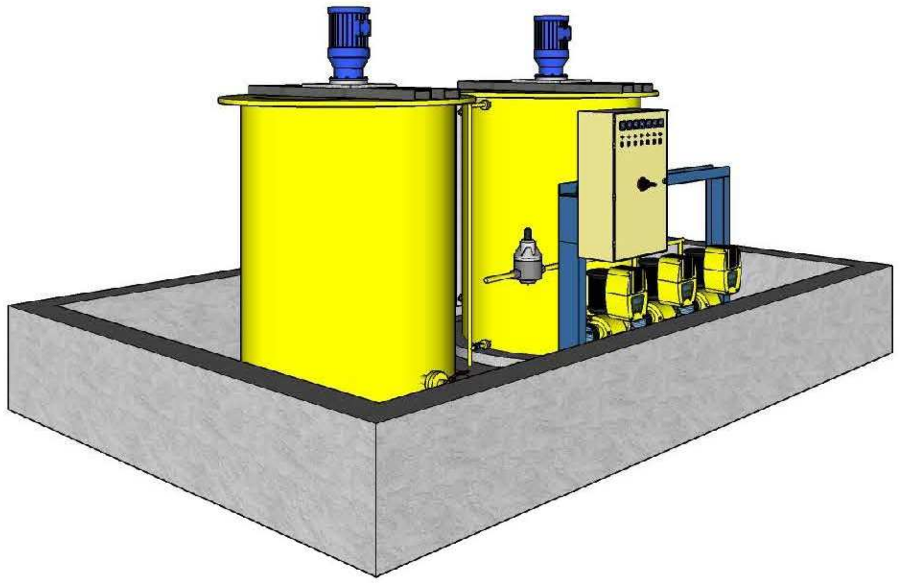
## Planta de Fortaleza

### 2.1- PRETRATAMIENTO QUÍMICO DEL AGUA DE MAR

### DESENHO DOS EQUIPAMENTOS DE DOSAGEM



| PRODUTOS QUIMICOS | |
|---|---|
| DISPERSANTE | 2 x 500 L |
| METABISULFITO SODICO | 2 x 1000 L |
| HIDROXIDO CALCICO | |
| FLUOROSILICATO DE SODIO | 2 x 1000 L |

| |
|---|
| **Fortaleza** |
| **QUIPAMENTOS DE DOSAGEM (SÓLIDO)** |
| Planta de Fortaleza |

Source: GS Inima



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## Planta de Fortaleza

**ANÁLISE DA AGUA DO MAR DEPOIS DO PRÉ TRATAMENTO**

| ANÁLISE FISICO-QUIMICO | | | | | |
|---|---|---|---|---|---|
| TURBIDEZ | 0,0 | U.N.F. | PH | 7,23 | |
| COR | 0,0 | Pt-Co | CONDUTIBILIDADE | 58.847,42 | µmhos/cm. |
| ODOR | 0,0 | TON | T.D.S. | 39.055,81 | mg/L |
| ASPECTO | | | ALCALINIDADE | 122,08 | ppm CO3Ca |
| TEMPERATURA | 27 | ºC | DUREZAE | 6.403,60 | ppm CO3Ca |
| **COMPOSIÇÃO IONICA** | | | | | |
| **ELEMENTO** | **mg/L** | **meq/l** | **ELEMENTO** | **mg/L** | **meq/l** |
| Ca++ | 504,55 | 25,18 | SO4= | 4.166,62 | 86,75 |
| Mg++ | 1.249,42 | 102,78 | Cl- | 20.428,38 | 576,21 |
| Na+ | 12.110,61 | 526,75 | CO3H- | 144,43 | 2,37 |
| K+ | 420,00 | 10,74 | F- | 0,30 | 0,02 |
| Ba++ | 0,02 | 0,00 | Br- | 0,00 | 0,00 |
| Sr++ | 5,10 | 0,12 | I- | 0,00 | 0,00 |
| Fe++ | 0,00 | 0,00 | NO2- | 0,00 | 0,00 |
| NH4+ | 0,30 | 0,02 | NO3- | 10,70 | 0,17 |
| Ag+ | 0,00 | 0,00 | CO3= | 2,17 | 0,07 |
| Mn++ | 0,00 | 0,00 | PO4= | 0,00 | 0,00 |
| Zn++ | 0,00 | 0,00 | S= | 0,00 | 0,00 |
| Cu++ | 0,00 | 0,00 | SiO2 (coloidal) | 0,04 | 0,00 |
| Al+++ | 0,00 | 0,00 | SiO2 (soluble) | 8,20 | 0,14 |
| Fe+++ | 0,00 | 0,00 | CO2 | 5,81 | 0,13 |
| H+ | | 0,00 | OH- | | 0,00 |
| **TOTAL** | **14.290,00** | **665,59** | **TOTAL** | **24.760,80** | **665,59** |

| OUTRAS DETERMINAÇÕES | | | |
|---|---|---|---|
| **SUBSTÂNCIAS TOXICAS** | **mg/L** | **Matéria orgânica e outros** | **mg/L** |
| Arsênio | 0,00 | DBO5 | 0,04 |
| Cádmo | 0,00 | DQO | 0,10 |
| Bário | 5,00 | Nitrogêno proteico | 0,00 |
| Mercurio | 0,00 | Compostos fenólicose | 0,00 |
| Chumbo | 0,00 | Detergentes | 0,00 |
| Selênio | 0,00 | Oleos e graxas | 0,00 |
| Cromo total | 0,00 | Hidrocarbonetos | 0,00 |
| Cromo | 0,00 | Sólidos em suspensão | 0,20 |

## Planta de Fortaleza

**Análise da agua do mar em impulsão de bombas de alta pressão**

| ANÁLISE FISICO-QUIMICO | | | | | |
|---|---|---|---|---|---|
| TURBIDEZ | 0,0 | U.N.F. | PH | 7,23 | |
| COR | 0,0 | Pt-Co | CONDUTIBILIDADE | 58.847,42 | µmhos/cm. |
| ODOR | 0,0 | TON | T.D.S. | 39.055,81 | mg/L |
| ASPECTO | | | ALCALINIDADE | 122,08 | ppm CO3Ca |
| TEMPERATURA | 27 | ºC | DUREZAE | 6.403,60 | ppm CO3Ca |
| **COMPOSIÇÃO IONICA** | | | | | |
| **ELEMENTO** | **mg/L** | **meq/l** | **ELEMENTO** | **mg/L** | **meq/l** |
| Ca++ | 504,55 | 25,18 | SO4= | 4.166,62 | 86,75 |
| Mg++ | 1.249,42 | 102,78 | Cl- | 20.428,38 | 576,21 |
| Na+ | 12.110,61 | 526,75 | CO3H- | 144,43 | 2,37 |
| K+ | 420,00 | 10,74 | F- | 0,30 | 0,02 |
| Ba++ | 0,02 | 0,00 | Br- | 0,00 | 0,00 |
| Sr++ | 5,10 | 0,12 | I- | 0,00 | 0,00 |
| Fe++ | 0,00 | 0,00 | NO2- | 0,00 | 0,00 |
| NH4+ | 0,30 | 0,02 | NO3- | 10,70 | 0,17 |
| Ag+ | 0,00 | 0,00 | CO3= | 2,17 | 0,07 |
| Mn++ | 0,00 | 0,00 | PO4= | 0,00 | 0,00 |
| Zn++ | 0,00 | 0,00 | S= | 0,00 | 0,00 |
| Cu++ | 0,00 | 0,00 | SiO2 (coloidal) | 0,04 | 0,00 |
| Al+++ | 0,00 | 0,00 | SiO2 (soluble) | 8,20 | 0,14 |
| Fe+++ | 0,00 | 0,00 | CO2 | 5,81 | 0,13 |
| H+ | | 0,00 | OH- | | 0,00 |
| **TOTAL** | **14.290,00** | **665,59** | **TOTAL** | **24.760,80** | **665,59** |

| OUTRAS DETERMINAÇÕES | | | |
|---|---|---|---|
| **SUBSTÂNCIAS TOXICAS** | **mg/L** | **Matéria orgânica e outros** | **mg/L** |
| Arsênio | 0,00 | DBO5 | 0,04 |
| Cádmo | 0,00 | DQO | 0,10 |
| Bário | 5,00 | Nitrogêno proteico | 0,00 |
| Mercurio | 0,00 | Compostos fenólicose | 0,00 |
| Chumbo | 0,00 | Detergentes | 0,00 |
| Selênio | 0,00 | Oleos e graxas | 0,00 |
| Cromo total | 0,00 | Hidrocarbonetos | 0,00 |
| Cromo | 0,00 | Sólidos em suspensão | 0,20 |

Source: GS Inima



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## Planta de Fortaleza

**ANALISE DA AGUA BRUTA PARA DISENHO DAS MEMBRANAS**

| ANÁLISE FISICO-QUIMICO | | | | | |
|---|---|---|---|---|---|
| TURBIDEZ | 0,0 | U.N.F. | PH | 7,22 | |
| COR | 0,0 | Pt-Co | CONDUTIBILIDADE | 60.269,17 | µmhos/cm. |
| ODOR | 0,0 | TON | T.D.S. | 40.152,66 | mg/L |
| ASPECTO | | | ALCALINIDADE | 125,51 | ppm CO3Ca |
| TEMPERATURA | 27 | ºC | DUREZAE | 6.583,44 | ppm CO3Ca |
| **COMPOSIÇÃO IONICA** | | | | | |
| **ELEMENTO** | **mg/L** | **meq/l** | **ELEMENTO** | **mg/L** | **meq/l** |
| Ca++ | 518,72 | 25,88 | SO4= | 4.283,64 | 89,19 |
| Mg++ | 1.284,51 | 105,67 | Cl- | 21.002,11 | 592,39 |
| Na+ | 12.450,74 | 541,55 | CO3H- | 148,43 | 2,43 |
| K+ | 431,80 | 11,04 | F- | 0,31 | 0,02 |
| Ba++ | 0,02 | 0,00 | Br- | 0,00 | 0,00 |
| Sr++ | 5,24 | 0,12 | I- | 0,00 | 0,00 |
| Fe++ | 0,00 | 0,00 | NO2- | 0,00 | 0,00 |
| NH4+ | 0,31 | 0,02 | NO3- | 11,00 | 0,18 |
| Ag+ | 0,00 | 0,00 | CO3= | 2,26 | 0,08 |
| Mn++ | 0,00 | 0,00 | PO4= | 0,00 | 0,00 |
| Zn++ | 0,00 | 0,00 | S= | 0,00 | 0,00 |
| Cu++ | 0,00 | 0,00 | SiO2 (coloidal) | 0,04 | 0,00 |
| Al+++ | 0,00 | 0,00 | SiO2 (soluble) | 8,43 | 0,14 |
| Fe+++ | 0,00 | 0,00 | CO2 | 5,99 | 0,14 |
| H+ | | 0,00 | OH- | | 0,00 |
| **TOTAL** | **14.691,34** | **684,28** | **TOTAL** | **25.456,18** | **684,28** |

| OUTRAS DETERMINAÇÕES | | | |
|---|---|---|---|
| **SUBSTÂNCIAS TOXICAS** | **mg/L** | **Matéria orgânica e outros** | **mg/L** |
| Arsênio | 0,00 | DBO5 | 0,04 |
| Cádmo | 0,00 | DQO | 0,10 |
| Bário | 5,14 | Nitrogêno proteico | 0,00 |
| Mercurio | 0,00 | Compostos fenólicose | 0,00 |
| Chumbo | 0,00 | Detergentes | 0,00 |
| Selênio | 0,00 | Oleos e graxas | 0,00 |
| Cromo total | 0,00 | Hidrocarbonetos | 0,00 |
| Cromo | 0,00 | Sólidos em suspensão | 0,21 |

Source: GS Inima



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## 2.2.- PRÉ TRATAMENTO FÍSICO DA AGUA DO MAR

### DESENHO DA FILTRAÇÃO

2.2.1.- PRIMEIRA ETAPA DA FILTRAÇÃO

| | | |
|---|---|---|
| Vazão de agua do mar a filtrar para o processo | m3/h | 8.024,0 |
| Vazão de agua para deslocamento de filtros de 2ª etapa | m3/h | 1.146,3 |
| Tipo de filtros | | De pressão |
| Posição dos filtros | | Horizontal |
| Velocidade nominal de filtração | m/h | 6,5 |
| Superficie util de filtração de cada filtro | m2 | 88,43 |
| Número de filtros: | Uds. | 16 |
| Diâmetro interno do filtro | m | 4 |
| Comprimento cilindrico do filtro | m | 22 |
| Tipo de fundos: | ***** | Korbbogen DIN 28013 |
| Pressão de desenho do filtro | bars | 4,5 |
| Velocidade de filtração em operação | m/h | 5,7 |
| Numero de filtros na lavagem simultanea | Uds. | 1,0 |
| Velocidade de filtração enquanto lava | m/h | 6,0 |
| Perda de carga minima nos filtros | m.c.a. | 0,85 |
| Perda de carga maxima nos filtros | m.c.a. | 10 |
| Numero de bocais por filtro | Uds./m2 | 50 |
| Número de capas filtrantes: | | 3 |
| Material da capa superior | | antracito |
| Altura da capa superior | m | 0,7 |
| Tamanho efetivo da capa superior | mm. | 1,90 |
| Coeficiente de uniformidade | | 1,4 |
| Poder de corte do material | micras | 226 |
| Material da capa intermediaria | | Silex |
| Altura da capa intermediaria | m | 0,4 |
| Tamanho efetivo da capa intermediaria | mm | 0,60 |
| Coeficiente de uniformidade | | 1,45 |
| Poder de corte do material | micras | 93 |
| Material da capa inferior | | Silex |
| Altura da capa inferior | m | 0,2 |
| Tamanho efetivo da capa inferior | mm | 2,00 |
| Coeficiente de uniformidade | | 1,7 |
| Poder de corte do material | micras | 309 |



Source: GS Inima



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## Planta de Fortaleza

**2.2.- PRÉ TRATAMENTO FÍSICO DA AGUA DO MAR**

**DESENHO DA FILTRAÇÃO**

2.2.- SEGUNDA ETAPA DE FILTRAÇÃO

| | | |
|---|---|---|
| Vazão de agua do mar a filtrar para o processo | m3/h | 8.024 |
| Tipo de filtros | | De pressão |
| Posição dos filtros | | Horizontal |
| Velocidade nominal de filtração | m/h | 12 |
| Superficie util de filtração de cada filtro | m2 | 92,51 |
| Número de filtros: | Uds. | 8 |
| Diametro interior do filtro: | m | 4 |
| Comprimento cilindrico do filtro | m | 22 |
| Tipo de fundos: | ***** | Korbbogen DIN 28013 |
| Pressão do desenho do filtro: | bars | 4,5 |
| Velocidade de filtração em operação | m/h | 10,8 |
| Numero de filtros na lavagem simultanea | Uds. | 1 |
| Velocidade de filtração enquanto lava | m/h | 12,4 |
| Perda de carga minima nos filtros | m.c.a. | 4,82 |
| Perda de carga maxima nos filtros | m.c.a. | 10 |
| Numero de bocais por filtro | Uds./m2 | 52 |
| Número de capas filtrantes: | | 2 |
| Material da capa superior | | Silex |
| Altura da capa superior | m | 0,50 |
| Tamanho efetivo da capa superior | mm. | 0,30 |
| Coeficiente de uniformidade | | 1,4 |
| Poder de corte do material | micras | 46 |
| Material da capa inferior | | Silex |
| Altura da capa inferior | m | 0,2 |
| Tamanho efetivo da capa inferior | mm | 2,00 |
| Coeficiente de uniformidade | | 1,7 |
| Poder de corte do material | micras | 309 |

Source: GS Inima



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## Planta de Fortaleza

### 2.2.- PRÉ TRATAMENTO FÍSICO DA AGUA DO MAR

### DESENHO DA FILTRAÇÃO

2.2.3.- FILTROS DE CARTUCHO

| | | |
|---|---|---|
| Vazão de agua do mar a filtrar para o processo | m3/h | 8.024 |
| Tipo de filtros | | Cartucho |
| Posição dos filtros | | Vertical |
| Velocidade máxima em conexões | m/seg | 2,2 |
| Tipo de cartucho | | PP-1 |
| Modelo de cartucho: | | BOBINADO-1 |
| Material del cartucho: | | POLIPROPIL. |
| Número de cartuchos por filtro: | Uds. | 339 |
| Poder de corte do cartucho: | micras absol | 10 |
| Eficiencia da filtração | | 99,600% |
| Beta ratio: | | 5.000 |
| Vazão máximo por cartucho: | m3/h | 3,26 |
| Vazão real por cartucho: | m3/h | 2,96 |
| Diametro del cartucho: | mm. | 61 |
| Comprimento do cartucho | mm | 1.270 |
| Superficie filtrante do cartucho | m2 | 0,24 |
| Perda de carga | m.c.a. | 2,18 |
| Perda de carga maxima admissivel | bars | 2 |
| Perda de carga maxima desenho | m.c.a. | 10,6 |
| Número de filtros: | Uds. | 8 |
| Diâmetro interno do filtro | mm. | 1.700 |
| Altura do corpo do filtro: | mm. | 2.972 |
| Pressão de desenho do filtro: | bars | 4,5 |
| Velocidade de filtração em operação | m/h | 12,20 |
| Duração estimada dos cartuchos: | dias | 44 |
| Separação entre cartuchos: | mm. | 15 |

Source: GS Inima



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## Planta de Fortaleza

**2.2.- PRÉ TRATAMENTO FÍSICO DA AGUA DO MAR**

**DESENHO DA FILTRAÇÃO**

| 2.2.4.- SISTEMA DE LAVAGEM DOS FILTROS DE AREIA | | |
|---|---|---|
| lavarão a vez filtros de 1ª e 2ª etapa?: | não | |
| Número bombas en operação para lavagem: | Uds. | 2 |
| Número de bombas em reserva: | Uds. | 1 |
| Velocidade recomendada de lavagem | m/h | 43 |
| Vazão da bomba de lavagem | m3/h | 1.914 |
| Pressão de descarga da bomba de lavagem | Bars | 0,0 |
| Fuido de lavagem | | salmora |
| Vazão total de agua para lavagem dos filtros: | m3/h | 3.828 |
| Número de sopradores de lavagem em operação | Uds. | 2 |
| Número de sopradores de lavagem em reserva | Uds. | 1 |
| Velocidade do ar de lavagem | m/h | 50 |
| Vazão so ar dos sopradores | Nm3/h | 2.211 |
| Pressão de descarga da bomba dos sopradores | bars | 0,6 |
| Procedimento de lavagem | | água + ar |
| Tempo estimado do ciclo de lavagem | min. | 77 |
| Frequencia de lavagem filtros 1ª etapa: | lavagens/día | 1,48 |
| Frequencia de lavagem de filtros 2ª etapa | lavagens/día | 3,31 |

Source: GS Inima



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## Planta de Fortaleza

### 2.2.- PRÉ TRATAMENTO FÍSICO DA AGUA DO MAR

### DESENHO DA FILTRAÇÃO

2.2.5.- DOSIFICAÇÃO DO CARVÃO ATIVADO EM PÓ

| | | |
|---|---|---|
| Vazão de agua do mar a tratar | m3/h | 8.024 |
| Dose do produto puro | mg/L | 2,00 |
| Densidade do produto | kg/l | 0,45 |
| Densidade do produto | Kg/l | 10 |
| Quantidade do produto a dosar | gr/h | 16.048,0 |
| Quantidade do produto comercial | kg/h | 16,0 |
| Vazão do produto a dosar | l/h | 160 |
| Número de bombas dosadoras em operação | Uds. | 2 |
| Número de bombas dosadoras em reserva | Uds. | 1 |
| Vazão da dosagem por bomba | l/h | 80 |
| Vazão nominal da bomba dosadora | l/h | 160 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 0,37 |
| Tempo minimo da dissolução disponível | horas | 12 |
| Numero de tanques de dissolução | Uds. | 2 |
| Volume de cada tanque | litros | 1000 |
| Tempo real de dissolução disponivel | horas | 12,5 |
| Tempo de reserva do produto armazenado | dias | 5 |
| Numero de silos de armazenamento | Uds. | 1 |
| Volume de cada silo | m3 | 1 |
| Tempo real de reserva no armazenamento | dias | 5,8 |
| Consumo anual de produto por este conceito | Ton | 134,8 |

Source: GS Inima



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3.- PROCESSO DE OSMOSE INVERSA



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## Planta de Fortaleza

### 3.- PROCESSO DE OSMOSE INVERSA

**Desenho do sistema de alta pressão**

3.1.- POMBAS DE ALTA PRESSÃO

| | | |
|---|---|---|
| Vazão total de agua do mar a bombear | m3/h | 3.662 |
| Número de bombas em operação | Uds. | 4 |
| Número de bombas em reserva | Uds. | 0 |
| Vazão nominal da bomba: | m3/h | 915 |
| Temperatura do desenho | ºC | 27 |
| Densidade da agua do mar | Kg/l | 1,0255 |
| Viscosidade da agua do mar | cp. | 0,9260 |
| Pressão de descarga a vazão nominal | | |
| Perdas de carga em tanque intermediário | bars | 1,2 |
| Pressão de entrada da membranas | bars | 63,00 |
| Altura geométrica | bars | 0,34 |
| **Pressão total na descarga da bomba** | bars | 64,5 |
| Pressão na impulsão da bomba | bars | 10,00 |
| Pressão diferencial dinâmica total | m.c.l. | 542,6 |
| pressão de descarga a vazão zero | bars | 70,0 |
| Rendimento da bomba | | 85,0% |
| Rendimento do motor | | 97,5% |
| Potencia absorbida por cada bomba | Kw | 1.633 |
| Potencia total absorvida pelos motores: | Kw | 6.698 |

Source: GS Inima



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3.2.- BOMBA BOOSTER EM ALIMENTAÇÃO B.A.P.

| | | |
|---|---|---|
| Vazão total de agua do mar a bombear | m3/h | 3.662 |
| Número de bombas em operação | Uds. | 4 |
| Número de bombas em reserva | Uds. | 0 |
| Vazão nominal da bomba: | m3/h | 915 |
| Temperatura do desenho | ºC | 27 |
| Densidade da agua do mar | Kg/l | 1,0255 |
| Viscosidade da agua do mar | cp. | 0,9260 |
| Pressão de descarga a vazão nominal | | |
| Perdas de carga em tanque intermediário | bars | 0,88 |
| Pressão na aspiração da bomba de A.P.: | bars | 10,00 |
| Altura geométrica de impulsão | bars | 0,00 |
| **Pressão total na descarga da bomba** | bars | 10,88 |
| Pressão na impulsão da bomba | bars | 2,50 |
| Pressão diferencial dinâmica total | m.c.l. | 83,37 |
| pressão de descarga a vazão zero | bars | 12,00 |
| Rendimento da bomba | | 84,00% |
| Rendimento do motor | | 96,30% |
| Potencia absorbida por cada bomba | Kw | 254 |
| Potencia total absorvida pelos motores: | Kw | 1.055 |

Source: GS Inima



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## Planta de Fortaleza

### CALCULOS HIDRAULICOS

3.1.- Trem de alta pressão

| | | | | |
|---|---|---|---|---|
| Pressão de impulsão | 10 bars | Tipo de água a bombear | Do Mar | |
| Pressão de entrada da membranas | 63 bars | Tipo de fluido | Salmora | |
| Pressão de saida da membranas | 59,6 bars | | | |
| Cota geometrica de aspiração da bomba | 6,4 m | Temperatura do fluido bombeado | 27 | ºC |
| Cota geometrica ponto médio da estrutura | 9,8 m | Densidade do fluido bombeado | 1,0255 | Kg/l |
| Cota geometrica da entrada da salmoura | 5,50 m | Viscosidade do fluido bombeado | 0,9260 | cp. |
| Vazão da bomba de alta pressão | 915 m3/h | Densidade da salmora | 1,0509 | Kg/l |
| Vazão de agua por fila de estrutura | 44,4 m3/h | Viscosidade da salmora | 1,0067 | cp. |
| Vazão de rejeito salmora por fila de estrutura | 24,4 m3/h | | | |
| vazão de rejeito da salmora a S.I.P.: | 1.103 m3/h | Fator de segurança perda atrtito | 20 | % |

| | Tubulação | | | Vazão | Velocidade | Número de Reynolds | Perda de carga unitária | Comprimento equivalente | Outras perdas de carga | Perda de carga total | Perda por seção |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DN | D interior | Material | | | | | | | | |
| | (mm.) | (mm.) | ------------ | (m3/h) | (m/s) | ---------- | (m.c.a./Km.) | (m) | (m.c.a.) | (m.c.a.) | (m.c.a.) |
| Seção impulsão bomba | 350,0 | 333,4 | 904hMo | 915,4 | 2,91 | 1.075.434 | 34,09 | 110 | 0,91 | 4,6 | 12,3 |
| | 500,0 | 477,8 | 904hMo | 2.006,0 | 3,11 | 1.644.244 | 25,25 | 85 | 0,29 | 2,4 | |
| | 350,0 | 333,4 | 904hMo | 1.003,0 | 3,19 | 1.178.349 | 40,38 | 28 | 0,56 | 1,7 | |
| | 90,0 | 77,9 | 904hMo | 44,4 | 2,58 | 223.042 | 148,89 | 8 | 0,35 | 1,5 | |
| | 40,0 | 35,1 | 904hMo | 8,9 | 2,56 | 99.182 | 370,31 | 5 | 0,17 | 0,0 | |
| Seção de rejeito da salmora | 40,0 | 35,1 | 904hMo | 4,9 | 1,41 | 54.550 | 122,39 | 3 | 0,31 | 0,0 | 11,1 |
| | 90,0 | 77,9 | 904hMo | 24,4 | 1,42 | 122.673 | 49,21 | 11 | 0,26 | 1,5 | |
| | 250,0 | 254,5 | 904hMo | 551,7 | 3,01 | 848.937 | 49,70 | 43 | 1,13 | 3,2 | |
| | 400,0 | 381,0 | 904hMo | 1.103,3 | 2,69 | 1.134.144 | 25,14 | 52 | 1,12 | 2,4 | |
| | 400,0 | 381,0 | 904hMo | 1.103,3 | 2,69 | 1.134.144 | 25,14 | 44 | 0,91 | 2,0 | |

| Bomba de alta pressão | | S.I.P. | |
|---|---|---|---|
| Diferença de pressão no ponto de saida/entrada | 540,6 m.c.a. | Perda de carga nas tubulações de aspiração | 11,1 m.c.a. |
| Altura geométrica de impulsão | 3,44 m.c.a. | Altura geométrica entre saida estrutura | 4,47 m.c.a. |
| Perda de carga nas tubulações de impulsão bomba | 12,33 m.c.a. | Pressão de saida da membranas | 607,41 m.c.a. |
| T.D.H. a vazão normal da bomba: | 542,56 m.c.l. | Pressão de entrada | 58,90 bars |
| Pressão de descarga de bomba a vazão normal: | 64,55 bars | Número de rodetes da bomba: | 3 Uds. |
| Pressão na aspiração | 102,00 m.c.a. | Velocidade de giro: | 3000 r.p.m. |
| Tensão de vapor a tempertaura do mar | 0,37 m.c.a. | Velocidade específica: | 30,67 |
| | 109,18 m.c.l. | NPSH recomendado: | 24,83 m.c.l. |



Source: GS Inima



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## Planta de Fortaleza

3.1.- Trem de alta pressão: CÁLCULO DO COMPRIMENTO EQUIVALENTES

| | SEÇÃO IMPULSÃO BOMBA | | | | | SEÇÃO DE REJEITO DA SALMORA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DIAMETRO | 350 | 500 | 350 | 90 | 40 | 40 | 90 | 250 | 400 | 400 |
| SERVIÇO | BOMBA DE IMPULSÃO DE ALTA PRESSÃO | COLETOR DE IMPULSÃO DA ESTRUTURA | COLUNA DE DISTRIBUIÇÃO DA ESTRUTURA | TUB. DISTRIBUC HORIZON | ENTRADA DO TUBO DE PRESSÃO | SAIDA DO TUBO DE PRESSÃO | TUB. HORIZON COLETA REJEITO | COLUNA DE SAIDA DA ESTRUTURA | COLETOR DE SAIDA DA ESTRUTURA | TUBOS A S.I.P. |
| COMPRIMENTO RETO | 15 | 15 | 10 | 6 | 1 | 1 | 6 | 20 | 20 | 12 |
| CURVA 90º (RAIO COMPRIDO) | | | | | | | | | | |
| CURVA 90º (STANDARD) | 2 | 2 | 1 | | 1 | 1 | | 1 | 2 | 2 |
| CURVA 45º (STANDARD) | | | | | | | | | | |
| CURVA 45º (RAIO CURTO) | | | | | | | | | | |
| TE | | 4 | 1 | 1 | | 1 | | | 1 | 1 |
| TE | 1 | | | | 1 | | 1 | 1 | | |
| VÁLVULA BORBOLETA | | | | | | | | | | |
| V. RETENÇÃO | 1 | | | | | | | | | |
| V. GLOBO | | | | | | | | | | |
| V. COMPOERTA | | | | | | | | | | |
| V. ANGULO | | | | | | | | | | |
| COMPRIMENTO EQUIVALENTE | 109,5 | 85 | 27,5 | 7,8 | 4,6 | 3 | 11,4 | 42,5 | 52 | 44 |
| ENTRADA | 0 | | | 1 | | 1 | | | 1 | |
| SAIDA | 0 | 1 | | | 1 | | 1 | | | |
| REDUÇÃO | | 400 | 180 | | | | | 200 | | 100 |
| | | | 140 | | | | | 100 | | |
| | | | 100 | | | | | | | |
| ALARGAMENTO | 273 | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| VÁLVULAS DE MACHO | 1 | | | | | 1 | 1 | 1 | 1 | 1 |
| SOMA DO COEFICIENTE K | 2,1 | 0,6 | 1,0 | 1,0 | 0,5 | 2,9 | 2,4 | 2,3 | 2,9 | 2,3 |



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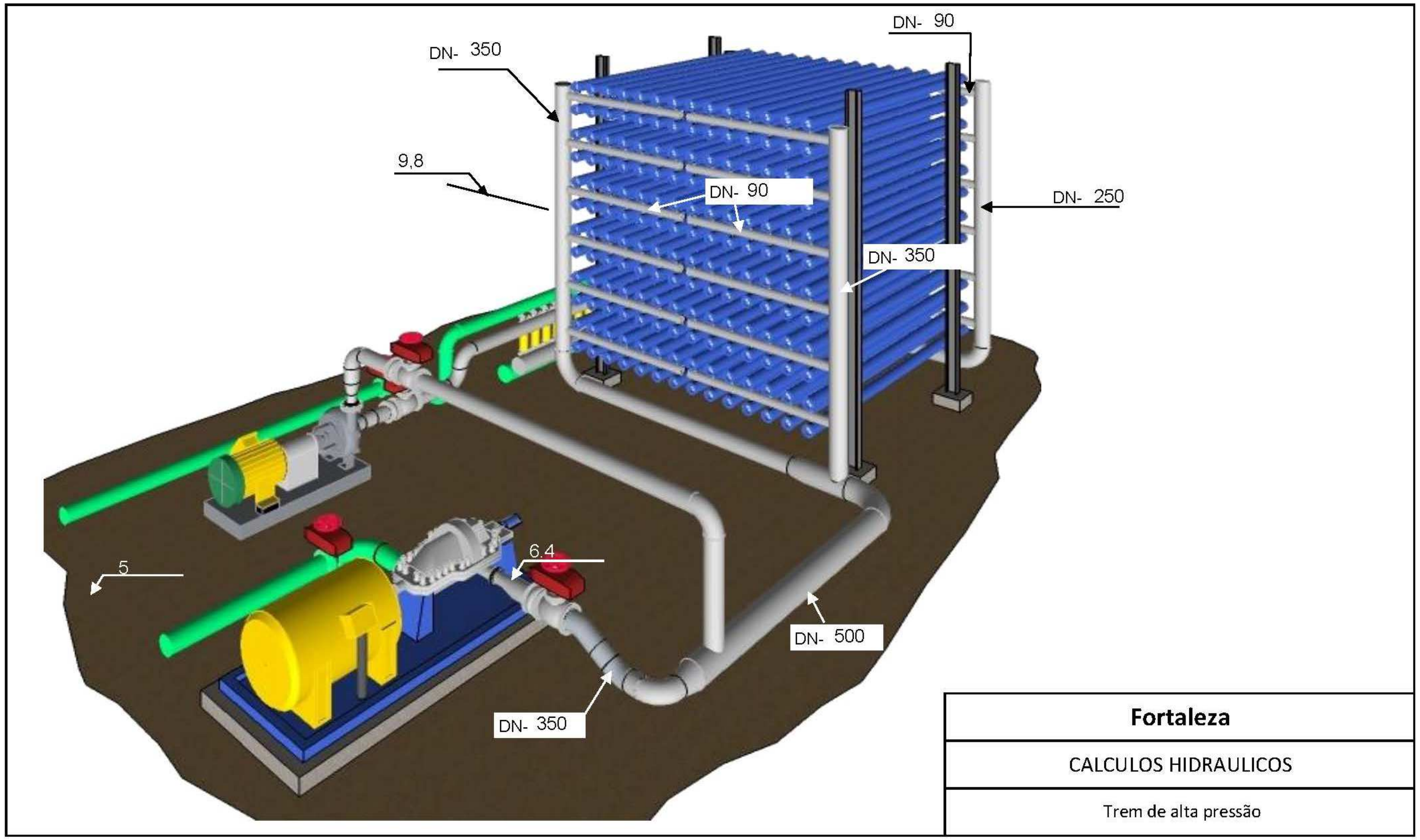
## Planta de Fortaleza




| Fortaleza |
| --- |
| CALCULOS HIDRAULICOS |
| Trem de alta pressão |

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## Planta de Fortaleza

### CALCULOS HIDRAULICOS

3.2.- BOMBA BOOSTER PARA BOMBA DE ALTA PRESSÃO

| | | | | |
|---|---|---|---|---|
| Pressão na aspiração da bomba booster: | 2,5 bars | | Tipo de água a bombear | Do Mar |
| Pressão na aspiração da bomba de A.P.: | 10 bars | | Tipo de fluido | Salmora |
| Cota geométrica aspiração da bomba booster: | 6,4 m | | Temperatura do fluido bombeado | 0 ºC |
| | | | Densidade do fluido bombeado | 1,0255 Kg/l |
| | | | Viscosidade do fluido bombeado | 0,9260 cp. |
| vazão da bomba booster de alta pressão | 915 m3/h | | Densidade da salmora | 1,0509 Kg/l |
| | | | Viscosidade da salmora | 1,0067 cp. |
| | | | Fator de segurança perda atrtito | 20 % |

| | DN | D interior | Material | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mm.) | (mm.) | ------------ | (m3/h) | (m/s) | ---------- | (m.c.a./Km.) | (m) | (m.c.a.) | (m.c.a.) | (m.c.a.) |
| | 350,0 | 333,4 | 904hMo | 915,4 | 2,91 | 1.075.434 | 34,09 | 102 | 1,03 | 4,5 | 9,0 |
| | 350,0 | 333,4 | 904hMo | 915,4 | 2,91 | 1.075.434 | 34,09 | 57 | 1,06 | 3,0 | |

| | | | | |
|---|---|---|---|---|
| Diferença de pressão no ponto de saida/entrada | 76,5 m.c.a. | | | |
| Altura geométrica de impulsão | 0,00 m.c.a. | | | |
| Perda de carga nas tubulações de impulsão bomba | 8,99 m.c.a. | | | |
| T.D.H. a vazão normal da bomba: | 83,37 m.c.l. | | | |
| Pressão de descarga de bomba a vazão normal: | 10,88 bars | | Número de rodetes da bomba: | 1 Uds. |
| Pressão na aspiração | 25,50 m.c.a. | | Velocidade de giro: | 1500 r.p.m. |
| Tensão de vapor a tempertaura do mar | 0,37 m.c.a. | | Velocidade específica: | 27,41 |
| N | | | | |

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## Planta de Fortaleza

3.2.- BOMBA BOOSTER PARA BOMBA DE ALTA P ESSÃO: CÁLCULO DO COMPRIMENTO EQUIVALENTES

| | SEÇÃO DE IMPULSÃO BOMBA BOOSTER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DIAMETRO | 350 | 350 | | | | | | | | |
| SERVIÇO | impulsão BOMBA BOOSTER | COLETOR DE IMPULSÃO DA ESTRUTURA | | | | | | | | |
| COMPRIMENTO RETO | 7 | 8 | | | | | | | | |
| CURVA 90º (RAIO COMPRIDO) | | | | | | | | | | |
| CURVA 90º (STANDARD) | 2 | 2 | | | | | | | | |
| CURVA 45º (STANDARD) | | | | | | | | | | |
| CURVA 45º (RAIO CURTO) | | | | | | | | | | |
| TE | | 4 | | | | | | | | |
| TE | 1 | | | | | | | | | |
| VÁLVULA BORBOLETA | | | | | | | | | | |
| V. RETENÇÃO | 1 | | | | | | | | | |
| V. GLOBO | | | | | | | | | | |
| V. COMPOERTA | | | | | | | | | | |
| V. ANGULO | | | | | | | | | | |
| COMPRIMENTO EQUIVALENTE | 101,5 | 57 | | | | | | | | |
| ENTRADA | 0 | | | | | | | | | |
| SAIDA | 0 | 1 | | | | | | | | |
| REDUÇÃO | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| ALARGAMENTO | 273 | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| VÁLVULAS DE MACHO | 1 | 1 | | | | | | | | |
| SOMA DO COEFICIENTE K | 2,3 | 2,4 | | | | | | | | |



Source: GS Inima



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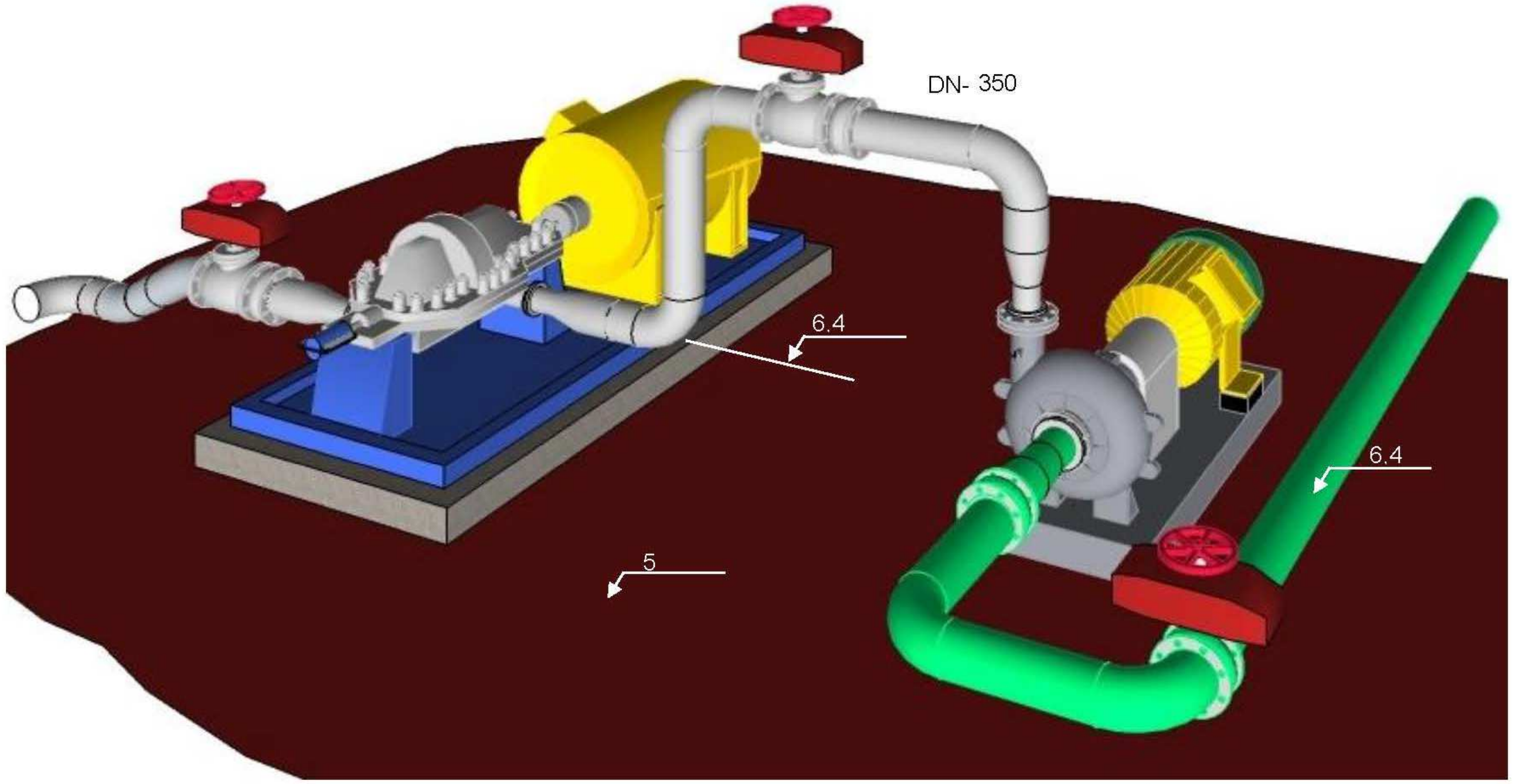
## Planta de Fortaleza




| Fortaleza |
|---|
| CALCULOS HIDRAULICOS |
| BOMBA BOOSTER PARA BOMBA DE ALTA PRESSÃO |



Source: GS Inima



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## Planta de Fortaleza

### 3.- PROCESSO DE OSMOSE INVERSA

### DESENHO DA RECUPERAÇÃO DE ENERGÍA POR SISTEMAS DE INTERCAMBIO DE PRESSÃO (S.I.P.)

| 3.3.- SISTEMA DE INTERCAMBIO DE PRESSÃO (S.I.P.) | | |
|---|---|---|
| Tipo de S.I.P. a utilizar: | | ERI |
| Modelo de S.I.P.: | | PX-Q300 |
| vazão total de salmora | m3/h | 4.413,20 |
| vazão total de salmora a partir dos S.I.P.: | m3/h | 4.413,20 |
| Pressão máxima salmora | bars | 82,70 |
| Pressão de entrada salmora | bars | 58,90 |
| Pressão de saida salmora | bars | 1,54 |
| vazão de agua do mar a partir das camaras: | m3/h | 4.362,40 |
| vazão de agua de mar | m3/h | 4.362,40 |
| Pressão min. entrada agua do mar | bars | 2,28 |
| Eficiencia | % | 97,20 |
| Número de elementos en operação | Uds. | 72 |
| Número de elementos em reserva: | Uds. | 0 |
| Número de elementos por estrutura | Uds. | 18,0 |
| vazão máximo de salmora/elemento: | m3/h | 68,00 |
| vazão real de salmora/elemento (incl reserv): | m3/h | 61,29 |
| Pressão de saida da agua do mar: | bars | 58,18 |
| Salinidade de entrada salmora: | ppm | 72.681,67 |
| Salinidade de saida salmora: | ppm | 70.687,35 |
| Salinidade saida da agua do mar: | ppm | 41.073,36 |
| Salinidade entrada agua do mar a membranas: | ppm | 40.152,69 |
| Máximo porcentagem de mistura | % | 6,00 |
| Número de rotações por minuto (max.): | r.p.m. | 800,00 |
| Número de rotações por minuto reais: | r.p.m. | 721,11 |
| Potência transmitida por la salmora: | Kw | 6.955,30 |
| Potência recuperada pela agua do mar: | Kw | 6.760,55 |
| Rendimento da recuperação | % | 96,34 |



Source: GS Inima



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## 3.- PROCESSO DE OSMOSE INVERSA

### DESENHO DA BOMBA DE RECIRCULAÇÃO

3.4.- BOMBA DE RECIRCULAÇÃO DOS S.I.P.

| | | |
|---|---|---|
| Vazão total de agua do mar a bombear | m3/h | 4.362 |
| Número de bombas em operação | Uds. | 4 |
| Número de bombas em reserva | Uds. | 0 |
| Vazão nominal da bomba: | m3/h | 1.090,6 |
| Temperatura do desenho | ºC | 27 |
| Densidade da agua do mar | Kg/l | 1,0255 |
| Viscosidade da agua do mar | cp. | 0,9260 |
| Pressão de descarga a vazão nominal | | |
| Perdas de carga em tanque intermediário | bars | 0,4 |
| Presão na tububação de alimentação de racks: | bars | 64,00 |
| Altura geométrica | bars | 0,00 |
| **Pressão total na descarga da bomba** | bars | 64,4 |
| Pressão na impulsão da bomba | bars | 57,50 |
| Pressão diferencial dinâmica total | m.c.l. | 68,5 |
| pressão de descarga a vazão zero | bars | 70,0 |
| Rendimento da bomba | | 83,0% |
| Rendimento do motor | | 96,3% |
| Potencia absorbida por cada bomba | Kw | 252 |
| Potencia total absorvida pelos motores: | Kw | 1.097 |



Source: GS Inima



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## Planta de Fortaleza

**CALCULOS HIDRAULICOS**

3.4.- BOMBA DE RECIRCULAÇÃO DOS S.I.P.

| | | | | |
|---|---|---|---|---|
| Pressão agua do mar saida S.I.P.: | 58,18 bars | | Tipo de água a bombear | Do Mar |
| Presão na tububação de alimentação de racks: | 64,0 bars | | Tipo de fluido alta pressão a S.I.P.: | salmuera |
| Pressão de saida da membranas | 59,6 bars | | Cota de saida da salmora de S.I.P.: | 5,50 m |
| Cota de la aspiração b. Recirculação | 6,4 m | | Temperatura do fluido bombeado | 27 ºC |
| Cota de la descarga da bomba de alta pressão | 6,4 m | | Densidade do fluido bombeado | 1,0255 Kg/l |
| Cota de entrada salmora a S.I.P.: | 5,50 m | | Viscosidade do fluido bombeado | 0,9260 cp. |
| vazão de la bomba de recirculação | 1.091 m3/h | | Densidade da salmora: | 1,0509 Kg/l |
| vazão total de agua do mar a S.I.P.: | 1.091 m3/h | | Viscosidade da salmora: | 1,0067 cp. |
| vazão de agua do mar a cada S.I.P.: | 61 m3/h | | | |
| vazão de salmora a S.I.P.: | 61,3 m3/h | | Fator de segurança perda atrtito | 20 % |

| | Tubulação | | | Vazão | Velocidade | Número de Reynolds | Perda de carga unitária | Comprimento equivalente | Outras perdas de carga | Perda de carga total | Perda por seção |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DN | D interior | Material | | | | | | | | |
| | (mm.) | (mm.) | ------------ | (m3/h) | (m/s) | ---------- | (m.c.a./Km.) | (m) | (m.c.a.) | (m.c.a.) | (m.c.a.) |
| Impulsão da bomba | 100,0 | 90,1 | 904hMo | 60,6 | 2,64 | 263.313 | 130,56 | 15 | 0,00 | 2,0 | 6,0 |
| | 400,0 | 381,0 | 904hMo | 1.090,6 | 2,66 | 1.121.089 | 24,61 | 42 | 0,18 | 1,2 | |
| | 400,0 | 381,0 | 904hMo | 1.090,6 | 2,66 | 1.121.089 | 24,61 | 46 | 0,70 | 1,8 | |
| | | | | | | | | | | | |
| Sessão da impulsão da bomba | 400,0 | 381,0 | 904hMo | 1.090,6 | 2,66 | 1.121.089 | 24,61 | 91 | 1,07 | 3,3 | 4,0 |
| | 400,0 | 381,0 | 904hMo | 1.090,6 | 2,66 | 1.121.089 | 24,61 | 0 | 0,00 | 0,0 | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

| SESSÃO DA IMPULSÃO DA BOMBA | | IMPULSÃO DA BOMBA | |
|---|---|---|---|
| Diferença de pressão no ponto de saida/entrada | 59,35 m.c.a. | Perda de carga nas tubulações de aspiração | 6,0 m.c.a. |
| Altura geométrica de impulsão | 0,00 m.c.a. | Tensão de vapor a tempertaura do mar | 0,36 m.c.a. |
| Perda de carga nas tubulações de impulsão bomba | 3,97 m.c.a. | N.P.S.H. disponivel | 581,68 m.c.l. |
| T.D.H. a vazão normal da bomba: | 68,51 m.c.l. | Pressão relativa na aspiração | 57,50 bars |
| Pressão de descarga de bomba a vazão normal: | 64,39 bars | Altura geométrica a partir S.I.P.-asp b recirc.: | -0,92 m.c.a. |
| | | Velocidade de giro: | 1500 r.p.m. |
| | | Velocidade específica: | 34,67 |
| | | NPSH recomendado: | 9,98 m.c.l. |



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## Planta de Fortaleza

3.4.- BOMBA DE RECIRCULAÇÃO DOS S.I.P.: CÁLCULO DO COMPRIMENTO EQUIVALENTES

| | IMPULSÃO DA BOMBA | | | | SESSÃO DA IMPULSÃO DA BOMBA | | | |
|---|---|---|---|---|---|---|---|---|
| DIAMETRO | 100 | 400 | 400 | | 400 | 400 | | |
| SERVIÇO | tubulação de saida | coletor | ASPIRAÇÃO BOMBAS DE RECIRCULAÇÃO | | IMPULSÃO BOMBAS DE RECIRCULAÇÃO | COLETOR IMPULSÃO B. RECIRCULAÇÃO | | |
| COMPRIMENTO RETO | 1 | 10 | 10 | | 7 | 0,1 | | |
| CURVA 90º (RAIO COMPRIDO) | | | | | | | | |
| CURVA 90º (STANDARD) | 2 | 2 | 3 | | 2 | | | |
| CURVA 45º (STANDARD) | | | | | | | | |
| CURVA 45º (RAIO CURTO) | | | | | | | | |
| TE | 1 | 1 | | | | | | |
| TE | 1 | | | | | | | |
| VÁLVULA BORBOLETA | | | | | | | | |
| V. RETENÇÃO | | | | | 1 | | | |
| V. GLOBO | | | | | | | | |
| V. COMPOERTA | | | | | | | | |
| V. ANGULO | | | | | | | | |
| COMPRIMENTO EQUIVALENTE | 15 | 42 | 46 | 0 | 91 | 0,1 | 0 | 0 |
| ENTRADA | | | | | 1 | | | |
| SAIDA | | 1 | | | | | | |
| REDUÇÃO | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| ALARGAMENTO | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| VÁLVULAS DE MACHO | | | 1 | | 1 | | | |
| SOMA DO COEFICIENTE K | 0 | 0,5 | 1,9 | 0 | 2,9 | 0 | 0 | 0 |

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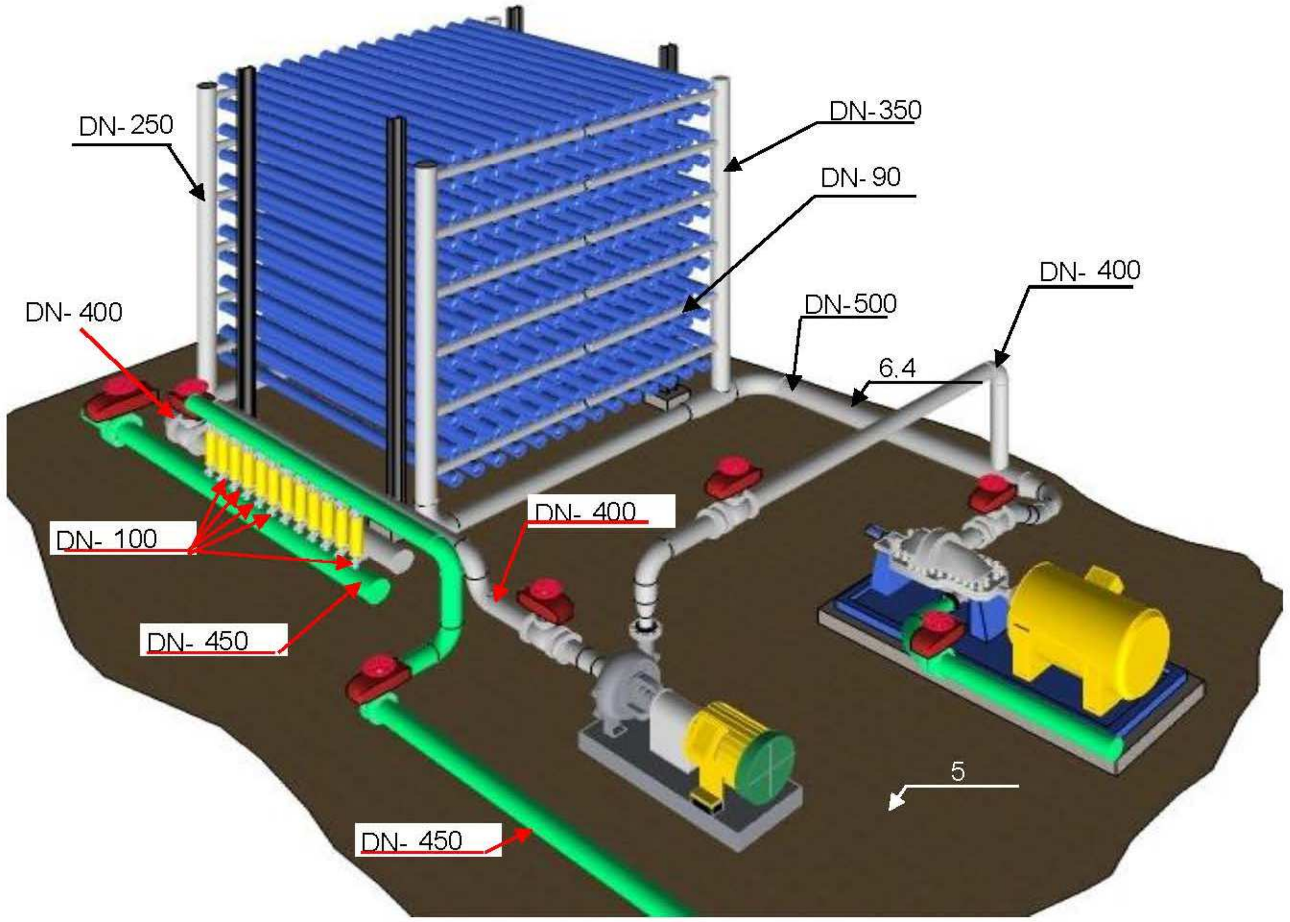
## Planta de Fortaleza




| Fortaleza |
|---|
| Planta de Fortaleza |
| BOMBA DE RECIRCULAÇÃO DOS S.I.P. |

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## Planta de Fortaleza

### 3.- PROCESSO DE OSMOSE INVERSA

### DESENHO DOS QUADROS DE MEMBRANAS

3.5.- MEMBRANAS DE OSMOSE INVERSA

| | | |
|---|---|---|
| Produção nominal de desenho | m3/d | 86.659 |
| Número total de linhas instaladas: | Uds. | 4 |
| Produção de desenho de cada linea: | m3/d | 21.665 |
| Temperatura de desenho (mínima): | ºC | 22 |
| Temperatura de desenho (máxima): | ºC | 30 |
| Tipo de membrana a instalar: | | Arrollamiento en espiral |
| Material da capa ativa: | | Poliamida aromática |
| Rejeito mínimo de sais | | 99,45% |
| Número de membranas por tubo: | Uds. | 7 |
| Número de etapas: | Uds. | 1 |
| Fluxo especifico medio de quadro | l/m2/h | 13,96 |
| 0 | l/m2/h | |
| 0 | l/m2/h | |
| pressão entrada com membranas limpas | bars | 61,4 |
| pressão entrada com membranas sujias | bars | 63 |



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## 3.- PROCESSO DE OSMOSE INVERSA

3.6.- CONFIGURAÇÃO DOS QUADROS

**PASSO Nº1**

| | | |
|---|---|---|
| Número de membranas Na 1ª etapa/linha | Uds. | 1582 |
| Número de tubos de pressão na 1ª etapa/linha | Uds. | 226 |
| Modelo de membranas de la 1ª etapa: | | SWC5 MAX |

**Estrutura**

| | | |
|---|---|---|
| Número de filas de tubos: | Uds. | 12 |
| Número de colunas de tubos: | Uds. | 20 |
| Nº de ocos livres de reserva para tubos: | Uds. | 14 |

**tubulações de distribução e forma do Estrutura**

| | | |
|---|---|---|
| Número de coletores verticais de alimentação e de saida salmora: | Uds. | 2 |
| Forma de distribução na estrutura | | Multiport |
| Número de coletores verticais de permeado na estrutura | Uds. | 2 |

**NOTA.-** ver desenho das membranas nas folhas do computador anexas



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Integrated Membranes Solutions Design Software, 2015

Created on: 08/01/2018 07:53:49

Nitto HYDRANAUTICS Nitto Group Company

**Permeate Throttling (Variable)**

| | | | | |
|---|---|---|---|---|
| Project name | FORTALEZA | | | Page : 1/3 |
| Calculated by | nsc | | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | | Raw water flow | 2006,00 m3/h |
| Feed pressure | 58,0 bar | | Permeate recovery | 45,00 % |
| Feed temperature | 22,0 °C(71,6°F) | | Element age | 0,0 years |
| Feed water pH | 7,22 | | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | | Fouling factor | 1,00 |
| Specific energy | 4,69 kwh/m3 | | SP increase, per year | 10,0 % |
| Pass NDP | 17,3 bar | | | |
| Average flux rate | 14,0 lmh | | | |
| | | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 901,8 | 8,9 | 4,9 | 13,9 | 1,3 | 30,2 | 1,05 | 1,1 | 0 | 56,6 | 206,8 | SWC5 MAX | 1582 | 226 x 7 |

| Ion (mg/l) | Raw Water | Feed Water | Permeate Water | Concentrate 1 |
|---|---|---|---|---|
| Hardness, as CaCO3 | 6586,89 | 6586,89 | 8,201 | 11959,8 |
| Ca | 520,00 | 520,00 | 0,647 | 944,2 |
| Mg | 1290,00 | 1290,00 | 1,606 | 2342,2 |
| Na | 12457,00 | 12457,00 | 74,354 | 22570,0 |
| K | 432,00 | 432,00 | 3,222 | 782,2 |
| NH4 | 0,00 | 0,00 | 0,000 | 0,0 |
| Ba | 0,020 | 0,020 | 0,000 | 0,0 |
| Sr | 5,250 | 5,250 | 0,007 | 9,5 |
| CO3 | 2,63 | 2,63 | 0,000 | 13,3 |
| HCO3 | 150,00 | 150,00 | 1,512 | 262,9 |
| SO4 | 4290,00 | 4290,00 | 6,020 | 7788,8 |
| Cl | 21000,00 | 21000,00 | 117,748 | 38054,8 |
| F | 0,31 | 0,31 | 0,003 | 0,6 |
| NO3 | 11,00 | 11,00 | 0,458 | 19,6 |
| PO4 | 0,00 | 0,00 | 0,000 | 0,0 |
| SiO2 | 8,50 | 8,50 | 0,036 | 15,4 |
| B | 5,00 | 5,00 | 1,172 | 8,1 |
| CO2 | 4,72 | 4,72 | 4,72 | 4,72 |
| **TDS** | **40171,71** | **40171,71** | **206,79** | **72811,64** |
| **pH** | **7,22** | **7,22** | **5,71** | **7,47** |

| **Saturations** | **Raw Water** | **Feed Water** | **Concentrate** | **Limits** |
|---|---|---|---|---|
| CaSO4 / ksp * 100, % | 39 | 39 | 82 | 400 |
| SrSO4 / ksp * 100, % | 24 | 24 | 51 | 1200 |
| BaSO4 / ksp * 100, % | 113 | 113 | 224 | 10000 |
| SiO2 saturation, % | 7 | 7 | 13 | 140 |
| CaF2 / ksp * 100, % | 0 | 0 | 0 | 1000 |
| Ca3(PO4)2 saturation index | 0,0 | 0,0 | 0,0 | 1,0 |
| Ionic strength | 0,80 | 0,80 | 1,44 | |
| Osmotic pressure, bar | 28,5 | 28,5 | 51,6 | |



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**Permeate Throttling (Variable)**

| | | | | |
|---|---|---|---|---|
| Project name | FORTALEZA | | | Page : 2/3 |
| Calculated by | nsc | | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | | Raw water flow | 2006,00 m3/h |
| Feed pressure | 58,0 bar | | Permeate recovery | 45,00 % |
| Feed temperature | 22,0 °C(71,6°F) | | Element age | 0,0 years |
| Feed water pH | 7,22 | | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | | Fouling factor | 1,00 |
| Specific energy | 4,69 kwh/m3 | | SP increase, per year | 10,0 % |
| Pass NDP | 17,3 bar | | | |
| Average flux rate | 14,0 lmh | | | |
| | | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 901,8 | 8,9 | 4,9 | 13,9 | 1,3 | 30,2 | 1,05 | 1,1 | 0 | 56,6 | 206,8 | SWC5 MAX | 1582 | 226 x 7 |

| Pass - Stage | Element no. | Feed Pressure bar | Pressure Drop bar | Conc Osmo. bar | NDP bar | Permeate Water Flow m3/h | Permeate Water Flux lmh | Beta | Permeate (Passwise cumulative) TDS | Ca | Mg | Na | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 1 | 58 | 0,3 | 33,1 | 24,5 | 1,2 | 30,2 | 1,05 | 71 | 0,222 | 0,551 | 25,531 | 40,429 |
| 1-1 | 2 | 57,7 | 0,2 | 37,6 | 19,6 | 0,9 | 22,6 | 1,05 | 87,2 | 0,273 | 0,677 | 31,349 | 49,643 |
| 1-1 | 3 | 57,5 | 0,2 | 41,8 | 15,5 | 0,7 | 16,5 | 1,03 | 105,6 | 0,33 | 0,819 | 37,953 | 60,101 |
| 1-1 | 4 | 57,3 | 0,2 | 45,2 | 11,5 | 0,5 | 11,4 | 1,03 | 127,6 | 0,399 | 0,991 | 45,878 | 72,652 |
| 1-1 | 5 | 57,1 | 0,2 | 47,9 | 8,4 | 0,3 | 7,8 | 1,02 | 152,2 | 0,476 | 1,181 | 54,704 | 86,628 |
| 1-1 | 6 | 56,9 | 0,1 | 50 | 6,2 | 0,2 | 5,4 | 1,02 | 178,6 | 0,559 | 1,387 | 64,218 | 101,695 |
| 1-1 | 7 | 56,8 | 0,1 | 51,6 | 4,5 | 0,2 | 3,7 | 1,01 | 206,8 | 0,647 | 1,606 | 74,354 | 117,748 |

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted. Version : 1.214.57 %

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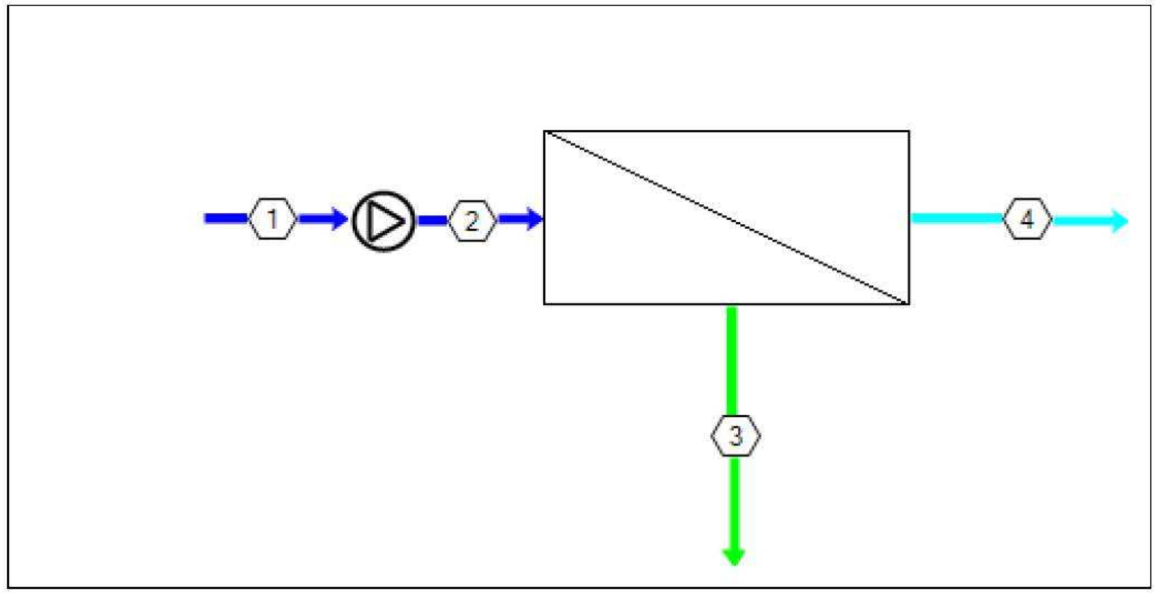
**Permeate Throttling (Variable)**

Project name FORTALEZA Page : 3/3

Temperature : 22,0 °C Element age, P1 : 0,0 years




| Stream No. | Flow (m3/h) | Pressure (bar) | TDS | pH | B |
|---|---|---|---|---|---|
| 1 | 2006 | 0 | 40172 | 7,22 | 5,00 |
| 2 | 2006 | 58,0 | 40172 | 7,22 | 5,00 |
| 3 | 1104 | 56,6 | 72812 | 7,47 | 8,13 |
| 4 | 902 | 1,10 | 207 | 5,71 | 1,17 |

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**Permeate Throttling (Variable)**

Project name FORTALEZA Page : 1/3

| | | | |
|---|---|---|---|
| Calculated by | nsc | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | Raw water flow | 2006,00 m3/h |
| Feed pressure | 60,9 bar | Permeate recovery | 45,00 % |
| Feed temperature | 22,0 °C(71,6°F) | Element age | 3,5 years |
| Feed water pH | 7,22 | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | Fouling factor | 0,78 |
| Specific energy | 4,92 kwh/m3 | SP increase, per year | 10,0 % |
| Pass NDP | 20,3 bar | | |
| Average flux rate | 14,0 lmh | | |
| | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 902,4 | 8,9 | 4,9 | 13,9 | 1,4 | 26,8 | 1,05 | 1,1 | 0 | 59,5 | 273,7 | SWC5 MAX | 1582 | 226 x 7 |

| Ion (mg/l) | Raw Water | Feed Water | Permeate Water | Concentrate 1 |
|---|---|---|---|---|
| Hardness, as CaCO3 | 6586,89 | 6586,89 | 10,862 | 11963,6 |
| Ca | 520,00 | 520,00 | 0,857 | 944,5 |
| Mg | 1290,00 | 1290,00 | 2,127 | 2343,0 |
| Na | 12457,00 | 12457,00 | 98,439 | 22561,6 |
| K | 432,00 | 432,00 | 4,265 | 781,7 |
| NH4 | 0,00 | 0,00 | 0,000 | 0,0 |
| Ba | 0,020 | 0,020 | 0,000 | 0,0 |
| Sr | 5,250 | 5,250 | 0,009 | 9,5 |
| CO3 | 2,63 | 2,63 | 0,000 | 13,3 |
| HCO3 | 150,00 | 150,00 | 2,001 | 262,5 |
| SO4 | 4290,00 | 4290,00 | 7,973 | 7791,1 |
| Cl | 21000,00 | 21000,00 | 155,891 | 38042,6 |
| F | 0,31 | 0,31 | 0,005 | 0,6 |
| NO3 | 11,00 | 11,00 | 0,605 | 19,5 |
| PO4 | 0,00 | 0,00 | 0,000 | 0,0 |
| SiO2 | 8,50 | 8,50 | 0,047 | 15,4 |
| B | 5,00 | 5,00 | 1,522 | 7,8 |
| CO2 | 4,72 | 4,72 | 4,72 | 4,72 |
| **TDS** | **40171,71** | **40171,71** | **273,74** | **72793,15** |
| **pH** | **7,22** | **7,22** | **5,82** | **7,47** |

| **Saturations** | **Raw Water** | **Feed Water** | **Concentrate** | **Limits** |
|---|---|---|---|---|
| CaSO4 / ksp * 100, % | 39 | 39 | 82 | 400 |
| SrSO4 / ksp * 100, % | 24 | 24 | 51 | 1200 |
| BaSO4 / ksp * 100, % | 113 | 113 | 224 | 10000 |
| SiO2 saturation, % | 7 | 7 | 13 | 140 |
| CaF2 / ksp * 100, % | 0 | 0 | 0 | 1000 |
| Ca3(PO4)2 saturation index | 0,0 | 0,0 | 0,0 | 1,0 |
| Ionic strength | 0,80 | 0,80 | 1,44 | |
| Osmotic pressure, bar | 28,5 | 28,5 | 51,6 | |

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### Permeate Throttling (Variable)

| | | | | |
|---|---|---|---|---|
| Project name | FORTALEZA | | | Page : 2/3 |
| Calculated by | nsc | | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | | Raw water flow | 2006,00 m3/h |
| Feed pressure | 60,9 bar | | Permeate recovery | 45,00 % |
| Feed temperature | 22,0 °C(71,6°F) | | Element age | 3,5 years |
| Feed water pH | 7,22 | | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | | Fouling factor | 0,78 |
| Specific energy | 4,92 kwh/m3 | | SP increase, per year | 10,0 % |
| Pass NDP | 20,3 bar | | | |
| Average flux rate | 14,0 lmh | | | |
| | | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 902,4 | 8,9 | 4,9 | 13,9 | 1,4 | 26,8 | 1,05 | 1,1 | 0 | 59,5 | 273,7 | SWC5 MAX | 1582 | 226 x 7 |

| Pass - Stage | Element no. | Feed Pressure bar | Pressure Drop bar | Conc Osmo. bar | NDP bar | Permeate Water Flow m3/h | Permeate Water Flux lmh | Beta | Permeate (Passwise cumulative) TDS | Ca | Mg | Na | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 1 | 60,9 | 0,3 | 32,5 | 28,1 | 1,1 | 26,8 | 1,05 | 106,3 | 0,333 | 0,825 | 38,214 | 60,513 |
| 1-1 | 2 | 60,6 | 0,2 | 36,5 | 23,6 | 0,9 | 21,2 | 1,04 | 126 | 0,394 | 0,978 | 45,305 | 71,742 |
| 1-1 | 3 | 60,4 | 0,2 | 40,5 | 19,6 | 0,7 | 16,5 | 1,03 | 148,9 | 0,466 | 1,156 | 53,545 | 84,792 |
| 1-1 | 4 | 60,2 | 0,2 | 44 | 15,6 | 0,5 | 12,2 | 1,03 | 175,9 | 0,551 | 1,366 | 63,258 | 100,173 |
| 1-1 | 5 | 60 | 0,2 | 47 | 12,4 | 0,4 | 9,2 | 1,02 | 206 | 0,645 | 1,6 | 74,052 | 117,269 |
| 1-1 | 6 | 59,8 | 0,2 | 49,5 | 9,7 | 0,3 | 6,8 | 1,02 | 238,6 | 0,747 | 1,854 | 85,813 | 135,894 |
| 1-1 | 7 | 59,7 | 0,1 | 51,6 | 7,5 | 0,2 | 4,9 | 1,01 | 273,7 | 0,857 | 2,127 | 98,439 | 155,891 |



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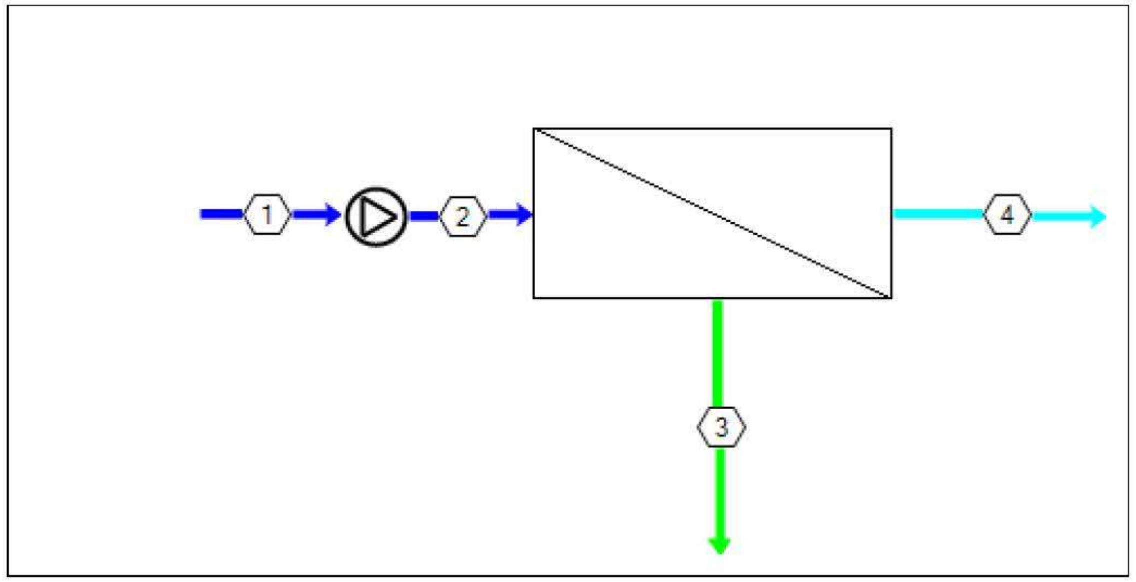
### Permeate Throttling (Variable)

| | | | |
|---|---|---|---|
| Project name | FORTALEZA | | Page : 3/3 |
| Temperature : | 22,0 °C | Element age, P1 : | 3,5 years |




| Stream No. | Flow (m3/h) | Pressure (bar) | TDS | pH | B |
|---|---|---|---|---|---|
| 1 | 2006 | 0 | 40172 | 7,22 | 5,00 |
| 2 | 2006 | 60,9 | 40172 | 7,22 | 5,00 |
| 3 | 1104 | 59,5 | 72793 | 7,47 | 7,84 |
| 4 | 902 | 1,10 | 274 | 5,82 | 1,52 |

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## Permeate Throttling (Variable)

| | | | |
|---|---|---|---|
| Project name | FORTALEZA | | Page : 1/3 |
| Calculated by | nsc | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | Raw water flow | 2006,00 m3/h |
| Feed pressure | 57,7 bar | Permeate recovery | 45,00 % |
| Feed temperature | 27,0 °C(80,6°F) | Element age | 0,0 years |
| Feed water pH | 7,22 | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | Fouling factor | 1,00 |
| Specific energy | 4,66 kwh/m3 | SP increase, per year | 10,0 % |
| Pass NDP | 16,2 bar | | |
| Average flux rate | 14,0 lmh | | |
| | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 902,4 | 8,9 | 4,9 | 13,9 | 1,3 | 32,9 | 1,06 | 1,1 | 0 | 56,4 | 255,9 | SWC5 MAX | 1582 | 226 x 7 |

| Ion (mg/l) | Raw Water | Feed Water | Permeate Water | Concentrate 1 |
|---|---|---|---|---|
| Hardness, as CaCO3 | 6586,89 | 6586,89 | 10,151 | 11964,3 |
| Ca | 520,00 | 520,00 | 0,801 | 944,5 |
| Mg | 1290,00 | 1290,00 | 1,988 | 2343,1 |
| Na | 12457,00 | 12457,00 | 92,010 | 22567,2 |
| K | 432,00 | 432,00 | 3,987 | 782,0 |
| NH4 | 0,00 | 0,00 | 0,000 | 0,0 |
| Ba | 0,020 | 0,020 | 0,000 | 0,0 |
| Sr | 5,250 | 5,250 | 0,008 | 9,5 |
| CO3 | 3,17 | 3,17 | 0,000 | 15,7 |
| HCO3 | 150,00 | 150,00 | 1,871 | 261,0 |
| SO4 | 4290,00 | 4290,00 | 7,452 | 7791,6 |
| Cl | 21000,00 | 21000,00 | 145,709 | 38051,5 |
| F | 0,31 | 0,31 | 0,004 | 0,6 |
| NO3 | 11,00 | 11,00 | 0,566 | 19,5 |
| PO4 | 0,00 | 0,00 | 0,000 | 0,0 |
| SiO2 | 8,50 | 8,50 | 0,044 | 15,4 |
| B | 5,00 | 5,00 | 1,498 | 7,9 |
| CO2 | 4,28 | 4,28 | 4,28 | 4,28 |
| **TDS** | **40172,25** | **40172,25** | **255,94** | **72809,70** |
| **pH** | **7,22** | **7,22** | **5,81** | **7,47** |

| **Saturations** | **Raw Water** | **Feed Water** | **Concentrate** | **Limits** |
|---|---|---|---|---|
| CaSO4 / ksp * 100, % | 38 | 38 | 80 | 400 |
| SrSO4 / ksp * 100, % | 24 | 24 | 50 | 1200 |
| BaSO4 / ksp * 100, % | 113 | 113 | 224 | 10000 |
| SiO2 saturation, % | 7 | 7 | 12 | 140 |
| CaF2 / ksp * 100, % | 0 | 0 | 0 | 1000 |
| Ca3(PO4)2 saturation index | 0,0 | 0,0 | 0,0 | 1,0 |
| Ionic strength | 0,80 | 0,80 | 1,44 | |
| Osmotic pressure, bar | 29,0 | 29,0 | 52,5 | |

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## Permeate Throttling (Variable)

| | | | |
|---|---|---|---|
| Project name | FORTALEZA | | Page : 2/3 |
| Calculated by | nsc | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | Raw water flow | 2006,00 m3/h |
| Feed pressure | 57,7 bar | Permeate recovery | 45,00 % |
| Feed temperature | 27,0 °C(80,6°F) | Element age | 0,0 years |
| Feed water pH | 7,22 | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | Fouling factor | 1,00 |
| Specific energy | 4,66 kwh/m3 | SP increase, per year | 10,0 % |
| Pass NDP | 16,2 bar | | |
| Average flux rate | 14,0 lmh | | |
| | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 902,4 | 8,9 | 4,9 | 13,9 | 1,3 | 32,9 | 1,06 | 1,1 | 0 | 56,4 | 255,9 | SWC5 MAX | 1582 | 226 x 7 |

| Pass - Stage | Element no. | Feed Pressure bar | Pressure Drop bar | Conc Osmo. bar | NDP bar | Permeate Water Flow m3/h | Permeate Water Flux lmh | Beta | Permeate (Passwise cumulative) TDS | Ca | Mg | Na | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 1 | 57,7 | 0,3 | 34,1 | 23,3 | 1,3 | 32,9 | 1,06 | 80,6 | 0,252 | 0,626 | 28,974 | 45,882 |
| 1-1 | 2 | 57,4 | 0,2 | 39 | 17,9 | 1 | 23,3 | 1,05 | 101,6 | 0,318 | 0,789 | 36,521 | 57,833 |
| 1-1 | 3 | 57,2 | 0,2 | 43,3 | 13,4 | 0,7 | 16 | 1,04 | 126,4 | 0,395 | 0,981 | 45,43 | 71,941 |
| 1-1 | 4 | 57 | 0,2 | 46,7 | 9,7 | 0,4 | 10,7 | 1,03 | 154,7 | 0,484 | 1,201 | 55,613 | 88,067 |
| 1-1 | 5 | 56,8 | 0,2 | 49,3 | 6,8 | 0,3 | 7 | 1,02 | 186,3 | 0,583 | 1,447 | 66,98 | 106,068 |
| 1-1 | 6 | 56,7 | 0,1 | 51,1 | 4,8 | 0,2 | 4,8 | 1,01 | 220,1 | 0,689 | 1,71 | 79,132 | 125,314 |
| 1-1 | 7 | 56,5 | 0,1 | 52,4 | 3,3 | 0,1 | 3,1 | 1,01 | 255,9 | 0,801 | 1,988 | 92,01 | 145,709 |

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CEP: 60.420-280 - Fortaleza - CE – Brasil
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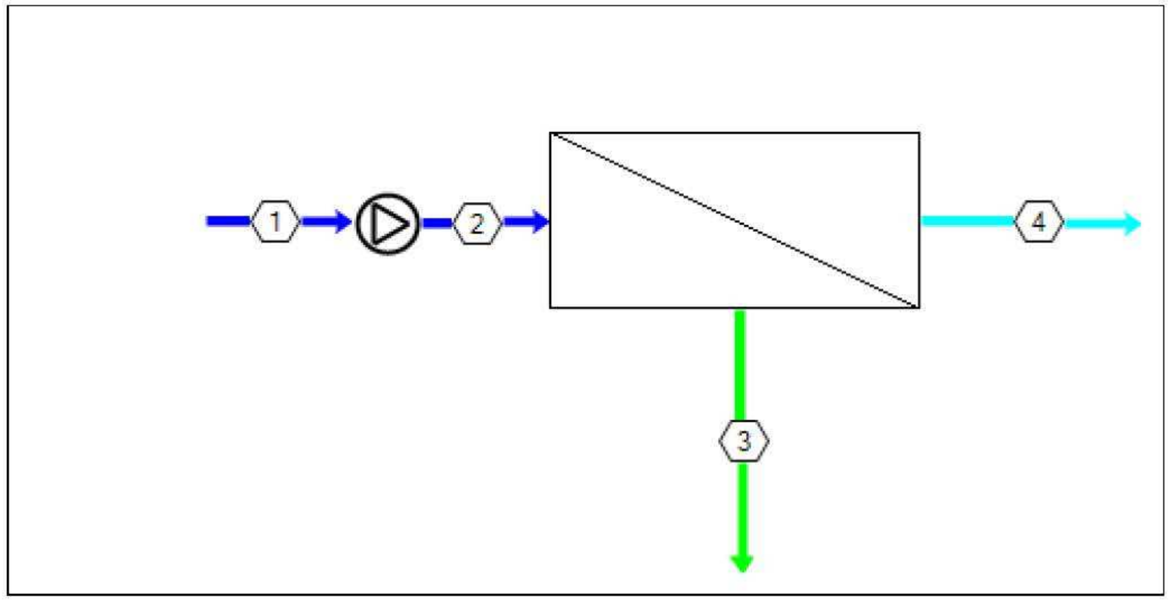
**Permeate Throttling (Variable)**

| | | | |
|---|---|---|---|
| Project name | FORTALEZA | | Page : 3/3 |
| Temperature : | 27,0 °C | Element age, P1 : | 0,0 years |




| Stream No. | Flow (m3/h) | Pressure (bar) | TDS | pH | B |
|---|---|---|---|---|---|
| 1 | 2006 | 0 | 40172 | 7,22 | 5,00 |
| 2 | 2006 | 57,7 | 40172 | 7,22 | 5,00 |
| 3 | 1104 | 56,4 | 72810 | 7,47 | 7,86 |
| 4 | 902 | 1,10 | 256 | 5,81 | 1,50 |



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**Permeate Throttling (Variable)**

| | | | |
|---|---|---|---|
| Project name | FORTALEZA | | Page : 1/3 |
| Calculated by | nsc | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | Raw water flow | 2006,00 m3/h |
| Feed pressure | 60,0 bar | Permeate recovery | 45,00 % |
| Feed temperature | 27,0 °C(80,6°F) | Element age | 3,5 years |
| Feed water pH | 7,22 | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | Fouling factor | 0,78 |
| Specific energy | 4,85 kwh/m3 | SP increase, per year | 10,0 % |
| Pass NDP | 18,8 bar | | |
| Average flux rate | 14,0 lmh | | |
| | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 902,4 | 8,9 | 4,9 | 13,9 | 1,4 | 29 | 1,05 | 1,1 | 0 | 58,7 | 338,1 | SWC5 MAX | 1582 | 226 x 7 |

| Ion (mg/l) | Raw Water | Feed Water | Permeate Water | Concentrate 1 |
|---|---|---|---|---|
| Hardness, as CaCO3 | 6586,89 | 6586,89 | 13,417 | 11961,4 |
| Ca | 520,00 | 520,00 | 1,059 | 944,3 |
| Mg | 1290,00 | 1290,00 | 2,628 | 2342,6 |
| Na | 12457,00 | 12457,00 | 121,552 | 22542,6 |
| K | 432,00 | 432,00 | 5,266 | 780,9 |
| NH4 | 0,00 | 0,00 | 0,000 | 0,0 |
| Ba | 0,020 | 0,020 | 0,000 | 0,0 |
| Sr | 5,250 | 5,250 | 0,011 | 9,5 |
| CO3 | 3,17 | 3,17 | 0,000 | 15,7 |
| HCO3 | 150,00 | 150,00 | 2,470 | 260,6 |
| SO4 | 4290,00 | 4290,00 | 9,849 | 7789,5 |
| Cl | 21000,00 | 21000,00 | 192,495 | 38012,4 |
| F | 0,31 | 0,31 | 0,006 | 0,6 |
| NO3 | 11,00 | 11,00 | 0,745 | 19,4 |
| PO4 | 0,00 | 0,00 | 0,000 | 0,0 |
| SiO2 | 8,50 | 8,50 | 0,058 | 15,4 |
| B | 5,00 | 5,00 | 1,931 | 7,5 |
| CO2 | 4,28 | 4,28 | 4,28 | 4,28 |
| **TDS** | **40172,25** | **40172,25** | **338,07** | **72740,93** |
| **pH** | **7,22** | **7,22** | **5,93** | **7,47** |

| **Saturations** | **Raw Water** | **Feed Water** | **Concentrate** | **Limits** |
|---|---|---|---|---|
| CaSO4 / ksp * 100, % | 38 | 38 | 80 | 400 |
| SrSO4 / ksp * 100, % | 24 | 24 | 50 | 1200 |
| BaSO4 / ksp * 100, % | 113 | 113 | 224 | 10000 |
| SiO2 saturation, % | 7 | 7 | 12 | 140 |
| CaF2 / ksp * 100, % | 0 | 0 | 0 | 1000 |
| Ca3(PO4)2 saturation index | 0,0 | 0,0 | 0,0 | 1,0 |
| Ionic strength | 0,80 | 0,80 | 1,44 | |
| Osmotic pressure, bar | 29,0 | 29,0 | 52,4 | |



Source: GS Inima



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## Permeate Throttling (Variable)

| | | | | |
|---|---|---|---|---|
| Project name | FORTALEZA | | | Page : 2/3 |
| Calculated by | nsc | | Permeate flow | 902,70 m3/h |
| HP Pump flow | | 2006,00 m3/h | Raw water flow | 2006,00 m3/h |
| Feed pressure | | 60,0 bar | Permeate recovery | 45,00 % |
| Feed temperature | | 27,0 °C(80,6°F) | Element age | 3,5 years |
| Feed water pH | | 7,22 | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | | None | Fouling factor | 0,78 |
| Specific energy | | 4,85 kwh/m3 | SP increase, per year | 10,0 % |
| Pass NDP | | 18,8 bar | | |
| Average flux rate | | 14,0 lmh | | |
| | | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 902,4 | 8,9 | 4,9 | 13,9 | 1,4 | 29 | 1,05 | 1,1 | 0 | 58,7 | 338,1 | SWC5 MAX | 1582 | 226 x 7 |

| Pass - Stage | Element no. | Feed Pressure bar | Pressure Drop bar | Conc Osmo. bar | NDP bar | Permeate Water Flow m3/h | Permeate Water Flux lmh | Beta | TDS | Ca | Mg | Na | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Permeate (Passwise cumulative) | | | | |
| 1-1 | 1 | 60 | 0,3 | 33,4 | 26,4 | 1,2 | 29 | 1,05 | 121,7 | 0,381 | 0,944 | 43,731 | 69,248 |
| 1-1 | 2 | 59,7 | 0,2 | 37,8 | 21,4 | 0,9 | 21,9 | 1,04 | 147,9 | 0,463 | 1,148 | 53,149 | 84,163 |
| 1-1 | 3 | 59,5 | 0,2 | 41,9 | 17,4 | 0,7 | 16,5 | 1,03 | 177,3 | 0,555 | 1,377 | 63,737 | 100,931 |
| 1-1 | 4 | 59,3 | 0,2 | 45,4 | 13,3 | 0,5 | 11,7 | 1,03 | 212,3 | 0,665 | 1,649 | 76,312 | 120,845 |
| 1-1 | 5 | 59,1 | 0,2 | 48,3 | 10,2 | 0,3 | 8,3 | 1,02 | 251,2 | 0,786 | 1,951 | 90,294 | 142,988 |
| 1-1 | 6 | 58,9 | 0,1 | 50,6 | 7,8 | 0,2 | 5,9 | 1,02 | 293,2 | 0,918 | 2,278 | 105,415 | 166,938 |
| 1-1 | 7 | 58,8 | 0,1 | 52,4 | 5,8 | 0,2 | 4,2 | 1,01 | 338,1 | 1,059 | 2,628 | 121,552 | 192,495 |



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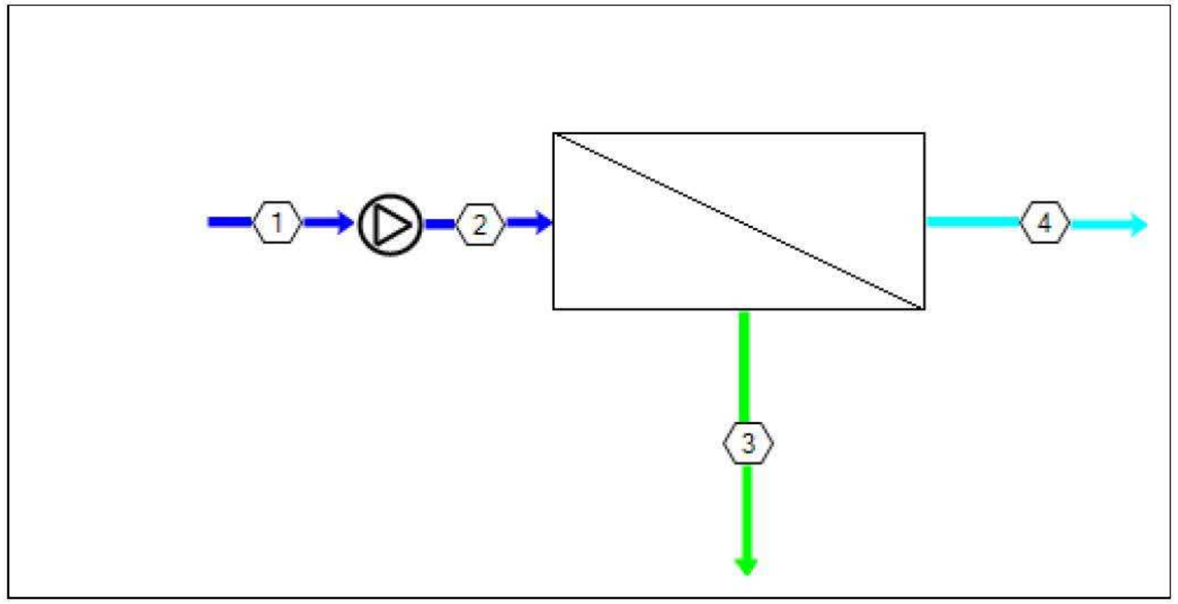
## Permeate Throttling (Variable)

| | | | |
|---|---|---|---|
| Project name | FORTALEZA | | Page : 3/3 |
| Temperature : | 27,0 °C | Element age, P1 : | 3,5 years |




| Stream No. | Flow (m3/h) | Pressure (bar) | TDS | pH | B |
|---|---|---|---|---|---|
| 1 | 2006 | 0 | 40172 | 7,22 | 5,00 |
| 2 | 2006 | 60,0 | 40172 | 7,22 | 5,00 |
| 3 | 1104 | 58,7 | 72741 | 7,47 | 7,51 |
| 4 | 902 | 1,10 | 338 | 5,93 | 1,93 |

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted. Version : 1.214.57 %

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## Permeate Throttling (Variable)

| | | | |
|---|---|---|---|
| Project name | FORTALEZA | | Page : 1/3 |
| Calculated by | nsc | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | Raw water flow | 2006,00 m3/h |
| Feed pressure | 59,6 bar | Permeate recovery | 45,00 % |
| Feed temperature | 30,0 °C(86,0°F) | Element age | 3,5 years |
| Feed water pH | 7,22 | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | Fouling factor | 0,78 |
| Specific energy | 4,82 kwh/m3 | SP increase, per year | 10,0 % |
| Pass NDP | 18,0 bar | | |
| Average flux rate | 14,0 lmh | | |
| | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 902,4 | 8,9 | 4,9 | 13,9 | 1,3 | 30,4 | 1,05 | 1,1 | 0 | 58,3 | 382,5 | SWC5 MAX | 1582 | 226 x 7 |

| Ion (mg/l) | Raw Water | Feed Water | Permeate Water | Concentrate 1 |
|---|---|---|---|---|
| Hardness, as CaCO3 | 6586,89 | 6586,89 | 15,184 | 11960,1 |
| Ca | 520,00 | 520,00 | 1,199 | 944,2 |
| Mg | 1290,00 | 1290,00 | 2,974 | 2342,3 |
| Na | 12457,00 | 12457,00 | 137,525 | 22529,8 |
| K | 432,00 | 432,00 | 5,957 | 780,3 |
| NH4 | 0,00 | 0,00 | 0,000 | 0,0 |
| Ba | 0,020 | 0,020 | 0,000 | 0,0 |
| Sr | 5,250 | 5,250 | 0,012 | 9,5 |
| CO3 | 3,53 | 3,53 | 0,000 | 17,3 |
| HCO3 | 150,00 | 150,00 | 2,794 | 259,4 |
| SO4 | 4290,00 | 4290,00 | 11,146 | 7788,5 |
| Cl | 21000,00 | 21000,00 | 217,792 | 37992,2 |
| F | 0,31 | 0,31 | 0,006 | 0,6 |
| NO3 | 11,00 | 11,00 | 0,841 | 19,3 |
| PO4 | 0,00 | 0,00 | 0,000 | 0,0 |
| SiO2 | 8,50 | 8,50 | 0,066 | 15,4 |
| B | 5,00 | 5,00 | 2,175 | 7,3 |
| CO2 | 4,05 | 4,05 | 4,05 | 4,05 |
| **TDS** | **40172,61** | **40172,61** | **382,49** | **72706,32** |
| **pH** | **7,22** | **7,22** | **5,99** | **7,47** |

| **Saturations** | **Raw Water** | **Feed Water** | **Concentrate** | **Limits** |
|---|---|---|---|---|
| CaSO4 / ksp * 100, % | 37 | 37 | 78 | 400 |
| SrSO4 / ksp * 100, % | 23 | 23 | 49 | 1200 |
| BaSO4 / ksp * 100, % | 113 | 113 | 224 | 10000 |
| SiO2 saturation, % | 6 | 6 | 11 | 140 |
| CaF2 / ksp * 100, % | 0 | 0 | 0 | 1000 |
| Ca3(PO4)2 saturation index | 0,0 | 0,0 | 0,0 | 1,0 |
| Ionic strength | 0,80 | 0,80 | 1,44 | |
| Osmotic pressure, bar | 29,2 | 29,2 | 52,9 | |



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## Permeate Throttling (Variable)

| | | | |
|---|---|---|---|
| Project name | FORTALEZA | | Page : 2/3 |
| Calculated by | nsc | Permeate flow | 902,70 m3/h |
| HP Pump flow | 2006,00 m3/h | Raw water flow | 2006,00 m3/h |
| Feed pressure | 59,6 bar | Permeate recovery | 45,00 % |
| Feed temperature | 30,0 °C(86,0°F) | Element age | 3,5 years |
| Feed water pH | 7,22 | Flux decline %, per year | 7,0 |
| Chem dose, mg/l, - | None | Fouling factor | 0,78 |
| Specific energy | 4,82 kwh/m3 | SP increase, per year | 10,0 % |
| Pass NDP | 18,0 bar | | |
| Average flux rate | 14,0 lmh | | |
| | | Feed type | Sea Surface Conventional |

| Pass - Stage | Perm. Flow m3/h | Flow / Vessel Feed m3/h | Flow / Vessel Conc m3/h | Flux lmh | DP bar | Flux Max lmh | Beta | Stagewise Pressure Perm. bar | Stagewise Pressure Boost bar | Stagewise Pressure Conc bar | Perm. TDS mg/l | Element Type | Element Quantity | PV# x Elem # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 902,4 | 8,9 | 4,9 | 13,9 | 1,3 | 30,4 | 1,05 | 1,1 | 0 | 58,3 | 382,5 | SWC5 MAX | 1582 | 226 x 7 |

| Pass - Stage | Element no. | Feed Pressure bar | Pressure Drop bar | Conc Osmo. bar | NDP bar | Permeate Water Flow m3/h | Permeate Water Flux lmh | Beta | Permeate (Passwise cumulative) TDS | Ca | Mg | Na | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 1 | 59,6 | 0,3 | 34 | 25,5 | 1,2 | 30,4 | 1,05 | 131,5 | 0,411 | 1,021 | 47,253 | 74,826 |
| 1-1 | 2 | 59,3 | 0,2 | 38,6 | 20,3 | 0,9 | 22,4 | 1,05 | 162 | 0,507 | 1,257 | 58,205 | 92,17 |
| 1-1 | 3 | 59,1 | 0,2 | 42,8 | 16,2 | 0,7 | 16,5 | 1,03 | 196,2 | 0,614 | 1,523 | 70,506 | 111,649 |
| 1-1 | 4 | 58,9 | 0,2 | 46,3 | 12,1 | 0,5 | 11,4 | 1,03 | 236,9 | 0,742 | 1,84 | 85,165 | 134,865 |
| 1-1 | 5 | 58,7 | 0,2 | 49,1 | 9 | 0,3 | 7,8 | 1,02 | 282,2 | 0,884 | 2,192 | 101,427 | 160,62 |
| 1-1 | 6 | 58,6 | 0,1 | 51,3 | 6,8 | 0,2 | 5,6 | 1,02 | 330,8 | 1,036 | 2,571 | 118,924 | 188,331 |
| 1-1 | 7 | 58,4 | 0,1 | 52,9 | 5 | 0,2 | 3,9 | 1,01 | 382,5 | 1,199 | 2,974 | 137,525 | 217,792 |

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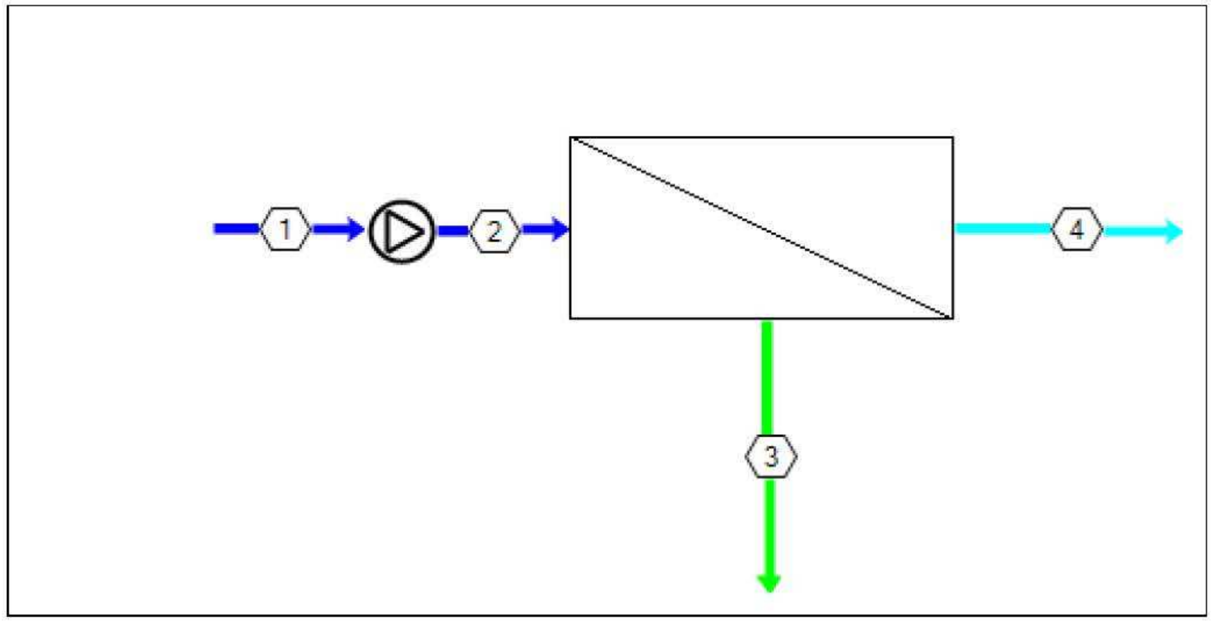
**Permeate Throttling (Variable)**

Project name FORTALEZA Page : 3/3

Temperature : 30,0 °C Element age, P1 : 3,5 years




| Stream No. | Flow (m3/h) | Pressure (bar) | TDS | pH | B |
|---|---|---|---|---|---|
| 1 | 2006 | 0 | 40173 | 7,22 | 5,00 |
| 2 | 2006 | 59,6 | 40173 | 7,22 | 5,00 |
| 3 | 1104 | 58,3 | 72706 | 7,47 | 7,31 |
| 4 | 902 | 1,10 | 382 | 5,99 | 2,17 |



Source: GS Inima



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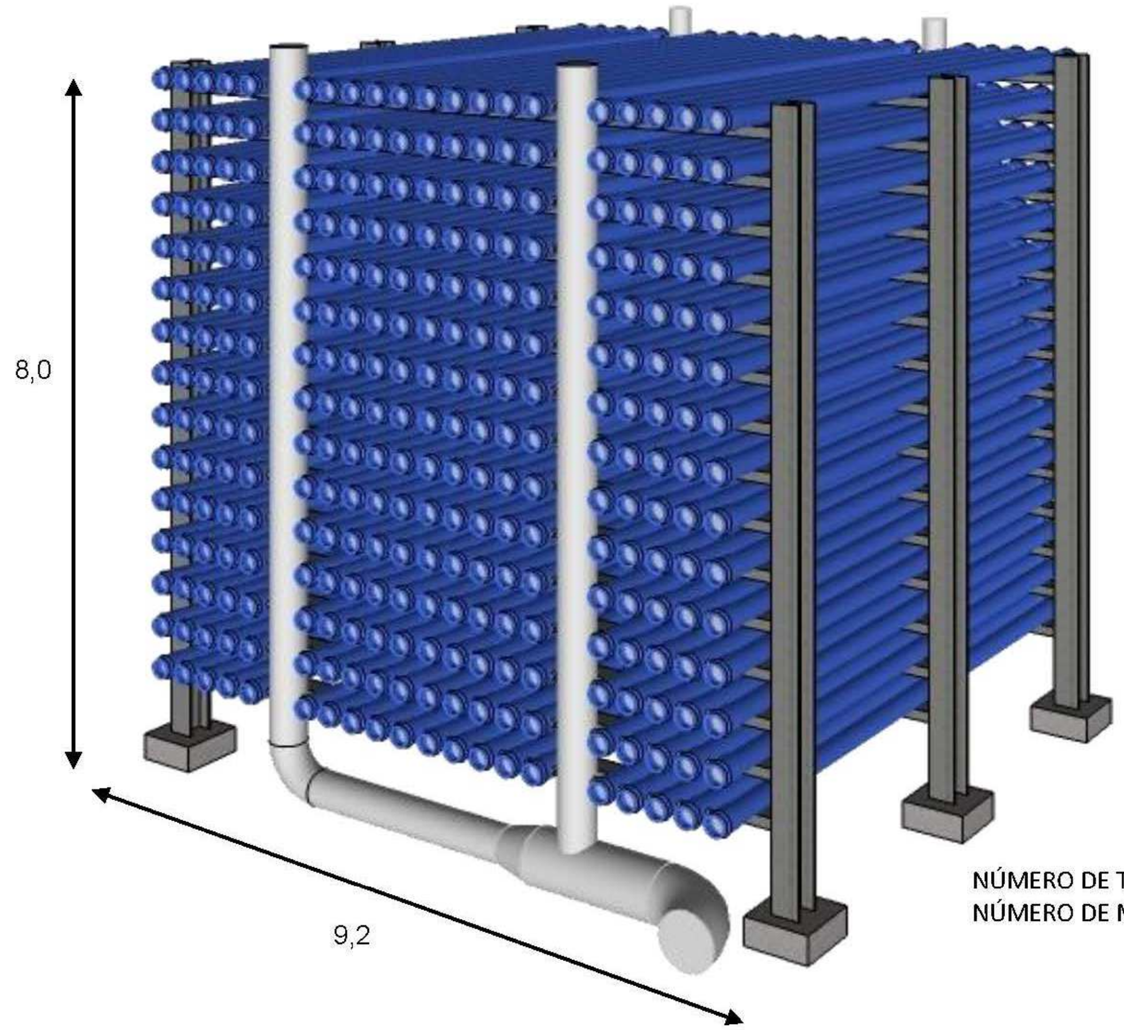
## Planta de Fortaleza




| | |
|---|---|
| NÚMERO DE TUBOS DE PRESSÃO/LINHA | 226 |
| NÚMERO DE MEMBRANAS/TUBO PRESSÃO | 7 |

**Fortaleza**

ESTRUTURA MULTIPORT

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## Planta de Fortaleza

**CALCULOS HIDRAULICOS**

SAIDA DO PRODUTO DA ESTRUTURA

| | | |
|---|---|---|
| Cota geométrica da entrada tanque de aspiração | 9,00 | m |
| Cota geométrica da altura minima em tanque aspir: | 5,5 | m |
| Cota geometrica ponto médio da estrutura | 9,75 | m |
| vazão de produto: | 3.610,8 | m3/h |
| vazão total de agua de produto por linha | 902,7 | m3/h |
| vazão total de água de produto a bombear: | 3.600,0 | m3/h |

| | | |
|---|---|---|
| Tipo de fluido | água permeada | |
| Temperatura do fluido bombeado: | 27 | ºC |
| Densidade do fluido bombeado: | 0,9967 | Kg/l |
| Viscosidade do fluido bombeado: | 0,8538 | cp. |
| Fator de segurança perda atrtito | 20 | % |
| Altura del tanque de armazenamento | 4,0 | m |
| Volume do tanque de armazenamento | 1.800 | m3 |

| | Tubulação | | | Vazão | Velocidade | Número de Reynolds | Perda de carga unitária | Comprimento equivalente | Outras perdas de carga | Perda de carga total | Perda por seção |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DN | D interior | Material | | | | | | | | |
| | (mm.) | (mm.) | ----------- | (m3/h) | (m/s) | ---------- | (m.c.a./Km.) | (m) | (m.c.a.) | (m.c.a.) | (m.c.a.) |
| Seção da estrutura a tanque de planta | 32,0 | 23,2 | POLIPROPI | 4,0 | 2,62 | 71.085 | 337,70 | 6 | 0,17 | 2,2 | 13,1 |
| | 110,0 | 79,8 | POLIPROPI | 39,9 | 2,22 | 206.664 | 58,53 | 16 | 4,34 | 5,2 | |
| | 300,0 | 300,0 | PRFV | 451,4 | 1,77 | 621.192 | 9,46 | 22 | 0,24 | 0,4 | |
| | 400,0 | 400,0 | PRFV | 902,7 | 2,00 | 931.788 | 8,41 | 129 | 0,20 | 1,3 | |
| | 800,0 | 800,0 | PRFV | 3.600 | 1,99 | 1.858.001 | 3,73 | 400 | 0,30 | 1,8 | |

| SAIDA DO PRODUTO DA ESTRUTURA | | |
|---|---|---|
| Altura geométrica a partir da estrutura a tanque aspiração | -0,75 | m.c.a. |
| Perda de carga nas tubulações de impulsão bomba | 13,1 | m.c.a. |
| Perdas de carga no misturador estático:" | 0,90 | m.c.a. |
| Pressão do produto a saida estrutura 1º passo: | 1,30 | bars |
| Pressão produto a tanque armazenamento: | 0,09 | bars |

| SAIDA PRODUTO ESTRUTURA 2º PASSO | | |
|---|---|---|
| Altura geométrica a partir da estrutura a tanque aspiração | #¡VALOR! | m.c.a. |
| Perdas de carga em tanque intermediário | #¡VALOR! | m.c.a. |
| Perdas de carga no misturador estático:" | #N/A | m.c.a. |
| Pressão do produto a saida estrutura 2º passo: | #¡VALOR! | bars |
| Perda de carga na válvula de controle: | 4,31 | m.c.a. |
| Pressão produto a tanque armazenamento: | #N/A | bars |



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## Planta de Fortaleza

SAIDA DO PRODUTO DA ESTRUTURA: CÁLCULO DO COMPRIMENTO EQUIVALENTES

| | SEÇÃO DA ESTRUTURA A TANQUE DE PLANTA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DIAMETRO | 32 | 110 | 300 | 400 | 800 | | | | | |
| SERVIÇO | SAIDA DO TUBO DE PRESSÃO | TUB. HORIZON COLETA PRODUZIDO | COLUNA DE SAIDA DA ESTRUTURA | COLETOR DE SAIDA DA ESTRUTURA | COLETOR PRODUC A TANQUE PLANTA | | | | | |
| COMPRIMENTO RETO | 3 | 10 | 13 | 22,6 | 200 | | | | | |
| CURVA 90º (RAIO COMPRIDO) | | | | | | | | | | |
| CURVA 90º (STANDARD) | 1 | 1 | 1 | 2 | 2 | | | | | |
| CURVA 45º (STANDARD) | | | | 1 | | | | | | |
| CURVA 45º (RAIO CURTO) | | | | | | | | | | |
| TE | 1 | 1 | | | | | | | | |
| TE | | | | | | | | | | |
| VÁLVULA BORBOLETA | 1 | | | 1 | 1 | | | | | |
| V. RETENÇÃO | | | | 1 | 1 | | | | | |
| V. GLOBO | | | | | | | | | | |
| V. COMPOERTA | | | | | | | | | | |
| V. ANGULO | | | | | | | | | | |
| COMPRIMENTO EQUIVALENTE | 5,88 | 15,5 | 22 | 129 | 400 | | | | | |
| ENTRADA | | | 1 | 1 | 1 | | | | | |
| SAIDA | 1 | | 1 | | 1 | | | | | |
| REDUÇÃO | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| ALARGAMENTO | | 250 | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| SOMA DO COEFICIENTE K | 0,5 | 17,34963459 | 1,5 | 1 | 1,5 | | | | | |



Source: GS Inima



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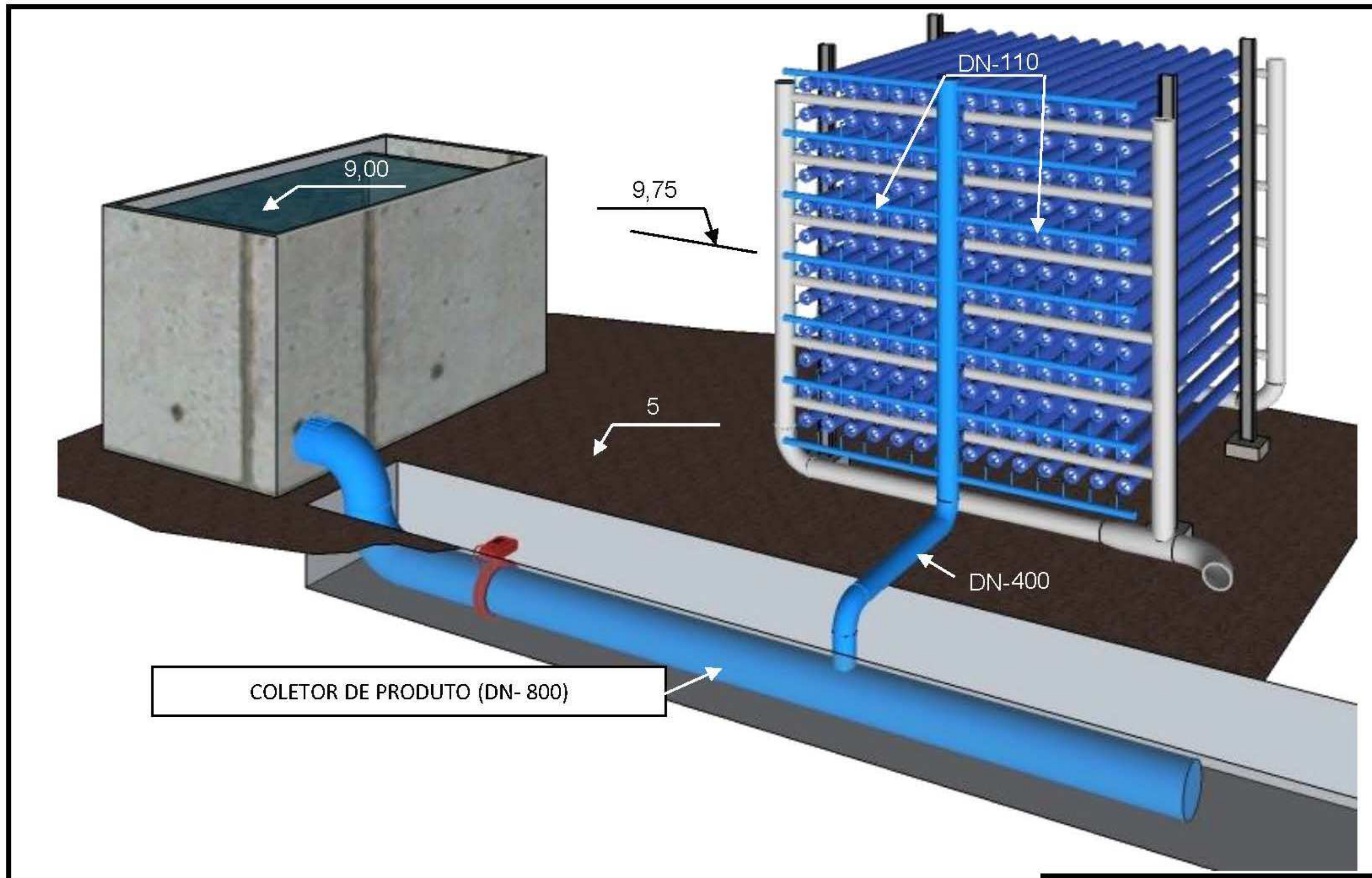
## Planta de Fortaleza




| |
|---|
| **Fortaleza** |
| CALCULOS HIDRAULICOS |
| **SAIDA DO PRODUTO DA ESTRUTURA** |

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Source: GS Inima



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## 4.- PÓS TRATAMENTO E BOMBEAMENTO DO PRODUTO





4.- PÓS TRATAMENTO E BOMBEAMENTO DO PRODUTO

### CÁLCULO DAS DOSAGENS

4.0.- COMPOSIÇÃO DO PRODUTO DA SAIDA DAS MEMBRANAS

| | | | |
|---|---|---|---|
| Calcio | 2,20 mg/L | Bicarbonato | 2,80 mg/L |
| Magnesio | 3,00 mg/L | Sulfato | 11,50 mg/L |
| Sodio | 140,00 mg/L | cloro | 224,00 mg/L |
| Potassio | 6,00 mg/L | Carbonato | 0,00 mg/L |
| Estroncio | 0,01 mg/L | STD | 391,71 mg/L |
| Bário | 2,20 mg/L | Anh. Carbó | 5,81 mg/L |
| Temperat. | 27,0 ºC | pH | 5,83 |

4.1.- DOSAGEM DE ANHIDRIDO CARBÓNICO

$CO_2$ + $H_2O$ --------------- $CO_2$ dissolvido
44 44
35,00 Y5

Y5 = -35,00 mg/L

| COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM | | | |
|---|---|---|---|
| | | $CO_3^{=}$ = | 0,00 mg/L |
| $Ca^{++}$ = | 2,20 mg/L | $SO_4^{=}$ = | 11,50 mg/L |
| $Mg^{++}$ = | 3,00 mg/L | $Cl^{-}$ = | 224,00 mg/L |
| $Na^{+}$ = | 140,00 mg/L | $CO_3H^{-}$ = | 3,25 mg/L |
| $K^{+}$ = | 6,00 mg/L | TDS = | 392,17 mg/L |
| $Sr^{++}$ = | 0,01 mg/L | $CO_2$ = | 40,48 mg/L |
| alcalinidade | 2,67 | Condu(25ºC)= | 791,44 µmhos/cm. |
| pH(inicial)= | 5,83 | pH(final)= | 5,05 |
| Dureza como carbonato de calcio | | 17,84 mg/L | |
| Indice de Langelier= | | -5,66 | |

Source: GS Inima



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## Planta de Fortaleza

### 4.- PÓS TRATAMENTO E BOMBEAMENTO DO PRODUTO

### CÁLCULO DAS DOSAGENS

DOSAGEM DE HIDROXIDO DE CALCIO

| | | | | |
|---|---|---|---|---|
| $Ca(OH)_2$ + | $2CO_2$ ------------- | $2(CO_3H)^-$ + | $Ca^{++}$ |
| 74 | 88 | 122 | 40 |
| 35,00 | Y5 | Y3 | X1 |

X1 = 18,93 mg/L

Y3 = 57,64 mg/L

Y5 = 41,58 mg/L

| COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM | | | |
|---|---|---|---|
| | | $CO_3^{=}$ = | 1,32 mg/L |
| $Ca^{++}$ = | 21,13 mg/L | $SO_4^{=}$ = | 11,50 mg/L |
| $Mg^{++}$ = | 3,00 mg/L | $Cl^{-}$ = | 224,00 mg/L |
| $Na^{+}$ = | 140,00 mg/L | $CO_3H^{-}$ = | 57,53 mg/L |
| $K^{+}$ = | 6,00 mg/L | TDS = | 466,70 mg/L |
| $Sr^{++}$ = | 0,01 mg/L | $CO_2$ = | 0,36 mg/L |
| alcalinidade | 49,39 | Condu(25ºC)= | 878,74 µmhos/cm. |
| pH(inicial)= | 5,05 | pH(final)= | 8,35 |
| Dureza como carbonato de calcio | | 65,12 mg/L | |
| Indice de Langelier= | | -0,15 | |

## Planta de Fortaleza

### 4.- PÓS TRATAMENTO E BOMBEAMENTO DO PRODUTO

### CÁLCULO DAS DOSAGENS

DOSAGEM DE FLOURSILICATO DE SODIO

| | | | |
|---|---|---|---|
| $F_6SiNa_2$ ----------- | $6F^-$ + | $2Na^+$ + | $Si^{4+}$ |
| 188 | 114 | 46 | 28 |
| 1,00 | Y2 | X3 | |

Y2 = 0,61 mg/L

X3(Na+) = 0,24 mg/L

| COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM | | | |
|---|---|---|---|
| Fluor= | 0,61 mg/L | $CO_3^{=}$ = | 0,64 mg/L |
| $Ca^{++}$ = | 21,13 mg/L | $SO_4^{=}$ = | 11,50 mg/L |
| $Mg^{++}$ = | 3,00 mg/L | $Cl^{-}$ = | 224,00 mg/L |
| $Na^{+}$ = | 140,24 mg/L | $CO_3H^{-}$ = | 57,69 mg/L |
| $K^{+}$ = | 6,00 mg/L | TDS = | 466,42 mg/L |
| $Sr^{++}$ = | 0,01 mg/L | $CO_2$ = | 0,74 mg/L |
| alcalinidade | 48,38 | Condu(25ºC)= | 877,78 µmhos/cm. |
| pH(inicial)= | 8,35 | pH(final)= | 8,03 |
| Dureza como carbonato de calcio | | 65,12 mg/L | |
| Indice de Langelier= | | -0,47 | |

Source: GS Inima



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**Planta de Fortaleza**

## 4.- PÓS TRATAMENTO E BOMBEAMENTO DO PRODUTO

### CÁLCULO DAS DOSAGENS

DOSAGEM HIPOCLORITO DE SODIO

| | | | | | | |
|---|---|---|---|---|---|---|
| ClONa | + H2O | -------- | ClOH | + | NaOH | |
| 74,4 | 18 | | 52,5 | | 40 | |
| 10,33 | | | Y2 | | X3 | |

A quantidade do produto a dosar dependerá a quantidade de materia organica a eleminar, portanto é um dado que deverá ser ajustado na operação. Não obstante a experiencia nos diz que uma dose do produto de mg/L como cloro livre, é suficiente em geral

Y2 = 4,92 mg/L

X3 = 3,19 mg/L

| COMPOSIÇÃO IONICA ATRAVES DA DOSAGEM | | | |
|---|---|---|---|
| Fluor= | 0,61 mg/L | $CO3^{=}$ = | 2,40 mg/L |
| $Ca^{++}$ = | 21,13 mg/L | $SO4^{=}$ = | 11,50 mg/L |
| $Mg^{++}$ = | 3,00 mg/L | $Cl^{-}$ = | 227,33 mg/L |
| $Na^{+}$ = | 143,44 mg/L | $CO3H^{-}$ = | 56,66 mg/L |
| $K^{+}$ = | 6,00 mg/L | TDS = | 473,67 mg/L |
| $Sr^{++}$ = | 0,01 mg/L | CO2 = | 0,19 mg/L |
| alcalinidade | 50,48 | Condu(25ºC)= | 893,39 µmhos/cm. |
| pH(inicial)= | 8,03 | pH(final)= | 8,61 |
| Dureza como carbonato de calcio | | 65,12 mg/L | |
| Indice de Langelier= | | 0,11 | |

Source: GS Inima



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## Planta de Fortaleza

### 4.- PÓS TRATAMENTO E BOMBEAMENTO DO PRODUTO

### DESENHO DOS EQUIPAMENTOS DE DOSAGEM

4.1.- DOSAGEM DE ANHIDRIDO CARBÓNICO

| | | |
|---|---|---|
| vazão de agua a tratar: | m3/h | 3.611 |
| Dose do produto puro | mg/L. | 35 |
| Riqueza de produto comercial | % | 100 |
| Densidade do produto | % | 1,03 |
| Quantidade do produto a dosar | gr/h | 126.378,0 |
| Quantidade do produto comercial | kg/h | 126,4 |
| Vazão do produto a dosar | l/h | 123 |
| Número de vaporizadores de CO2 em operação | Uds. | 1 |
| Número de vaporizadores de CO2 em reserva: | Uds. | 1 |
| Vazão normal da dosagem | kg/h | 126 |
| Vazão maximo da dosagem | kg/h | 250 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 3 |

| | | |
|---|---|---|
| Tempo de reserva do produto armazenado | dias | 30 |
| Numero de tanques de armazenamento | Uds. | 2 |
| Capacidade de cada tanque de armazenamento | Ton | 40 |
| Tempo real de reserva no armazenamento | dias | 27,9 |
| Consumo anual de produto por este conceito | Ton | 1.061,6 |

Source: GS Inima



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## Planta de Fortaleza

4.2.- DOSAGEM DE HIDROXIDO DE CALCIO

| | | |
|---|---|---|
| 4.2.1.- TANQUE DE LEITE DE CAL | | |
| vazão de cal: | m3/h | 1,40 |
| Concentração da leite de cal | % | 10 |
| Numero de tanques de leite de cal: | Uds. | 2 |
| Volume do tanque de leite de cal: | m3 | 7,10 |
| Tempo disponivel para preparar uma cuba de leite | minutos | 303,4 |
| vazão de bombas de agua de cal | l/h | 351 |
| Pressão de descarga | bars | 2 |
| Potência do motor | Kw | 0,04 |
| Número de bombas de agua de cal em oper.: | Uds. | 4 |
| Número de bombas de agua de cal em reser.: | Uds. | 1 |
| Diametro do tanque de cal: | m | 2 |
| Altura do tanque de cal: | m | 4 |
| Potencia do agitador dacal: | kW | 2,5 |
| | | |
| 4.2.2.- SILOS DE CAL | | |
| Número de parafusos dosador | Uds. | 2,0 |
| Capacidade de cada parafuso dosador | kg/h | 138,86 |
| Potencia do motor do parafuso | Kw | 5 |
| Tempo de reserva do produto armazenado | dias | 30 |
| Consumo anual de produto por este conceito | Ton | 1.179,5 |
| Numero de silos de armazenamento | Uds. | 2 |
| Volume de  cada silo | m3 | 100,0 |
| Tempo real de reserva no armazenamento | dias | 29,7 |

Source: GS Inima



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## Planta de Fortaleza

DOSAGEM DE FLOURSILICATO DE SODIO

| | | |
|---|---|---|
| vazão de agua a tratar: | m3/h | 3.611 |
| Dose do produto puro | mg/L. | 1,00 |
| Riqueza de produto comercial | % | 98 |
| Diluição do produto | % | 10 |
| Quantidade do produto a dosar | gr/h | 3.610,8 |
| Quantidade do produto comercial | kg/h | 3,7 |
| Vazão do produto a dosar | l/h | 37 |
| Número de bombas dosadoras em operação | Uds. | 2 |
| Número de bombas dosadoras em reserva | Uds. | 1 |
| Vazão da dosagem por bomba | l/h | 18 |
| Vazão nominal da bomba dosadora | l/h | 40 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 0,22 |
| Tempo minimo da dissolução disponivel | horas | 24 |
| Numero de tanques de dissolução | Uds. | 2 |
| Volume de cada tanque | litros | 1.000 |
| Tempo real de dissolução disponivel | horas | 54,3 |
| Tempo de reserva do produto armazenado | dias | 30 |
| | | |
| Quantidade de produto a armazenar | Ton | 2,6 |
| Consumo anual de produto por este conceito | Ton | 30,9 |

Source: GS Inima



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**Planta de Fortaleza**

DOSAGEM HIPOCLORITO DE SODIO

| | | |
|---|---|---|
| vazão de agua a tratar: | m3/h | 3.611 |
| Dose do produto puro | mg/L. | 1 |
| Riqueza de produto comercial | gr/l | 120 |
| Densidade do produto | Kg/l | 1,24 |
| Quantidade do produto a dosar | gr/h | 3.610,8 |
| Quantidade do produto comercial | l/h | 30,1 |
| Vazão do produto a dosar | l/h | 30 |
| Número de bombas dosadoras em operação | Uds. | 2 |
| Número de bombas dosadoras em reserva | Uds. | 1 |
| Vazão da dosagem por bomba | l/h | 15 |
| Vazão nominal da bomba dosadora | l/h | 30 |
| Pressão de descarga | bars | 8 |
| Potência do motor | Kw | 0,37 |

| | | |
|---|---|---|
| Tempo de reserva do produto armazenado | dias | 30 |
| Numero de tanques de armazenamento | Uds. | 2 |
| Volume de cada tanque de armazenamento | m3 | 12 |
| Tempo real de reserva no armazenamento | dias | 31,6 |
| Consumo anual de produto por este conceito | Ton | 313,4 |

Source: GS Inima



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## 4. Product Water Pumping

**Treated Water Pumping Station**

**City of Fortaleza-CE**

### 1. Intake Flow Chart Summary

Pumping time ( $T_b$ ) --------------------------------------- : 24 h

Highest demand day coefficient ( $k_1$ ) --------------------------------- : 1.20

System Flow --------------------------------------- : $Q_{AAT(10)}$ : 3,600.00 m³/h

: 1000.00 L/s

: 1.00000 m³/s

### 2. Product Water Pressure Main - AAT-1

Length ( L ) - (Staking + Reserve + covering) ------- : **1,343.00 m**

Economic diameter ( D' ) ----------------------------- : 1,0x Q^0,5 : 1,000.00 mm

Adopted diameter ( D ) ------------------------------- : Diameter : **1,000 mm**

External diameter (Dext) ----------------------------- : **1,000 mm**

Thickness (E) -------------------------------------------- : **59.30 mm**

Internal diameter (Di) --------------------------------- : **881.40 mm**

Velocity ( V ) -------------------------------------------- : $\frac{Q}{\pi \times (D/2)^2}$ : 1.64 m/s

### 3. Treated Water Pumping Station - EEAT

Pressure piping rate ------------------------------------ : $C_R$ : 84.61 m

Suction rate ---------------------------------------- : $C_S$ : 13.49 m

Geometric height ( Hg ) ------------------------ : $C_R - C_S$ : 71.12 m

### 4. Calculation of Head Losses Throughout Piping

#### *4.1. Head losses throughout piping*

Temperature ------------------------------------------------ : **20 ºC**

v (Kinematic Viscosity) ----------------------------------- : **1.01E-06 m²/s**

ε (Roughness Coefficient) ------------------------------ : **0.00150 mm**

g (Gravity) ------------------------------------------------ : **9.81 m/s²**

Reynolds Number (Re) --------------------------- $Re = \frac{VD}{\vartheta}$ : **1,434,523**

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon}{3{,}71D} + \frac{2{,}51}{R\sqrt{f}}\right)$$

Friction Factor --------------------------------------------- : **0.0110000**

$$h_f = f\frac{L}{D}\frac{V^2}{2g}$$

Distributed head loss **0.001506 m/m**

Head loss by length (J) **2.02254 m**

Material Coefficient ( K ) ------------------------------------ : **18.0**

Piping Thickness ( E ) --------------------------------------- : **59.3 mm**

#### *4.2. Local Head Loss*

Gravity acceleration ( g ) ------------------------------------------ : 9.807 m/s²

Suction flow -------------------------------------------------------- : 250.000 l/s



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| | | |
|---|---|---|
| Suction diameter | : | 1,000.00 mm |
| External diameter (Dext) | : | **1,000 mm** |
| Thickness (E) | : | **59.30 mm** |
| Internal Diameter (Di) | : | **881.40 mm** |
| Suction velocity (v) | : | 0.410 m/s |

**SUCTION**

| PARTS | | Qtde | | KUNIT. | | KTOTAL |
|---|---|---|---|---|---|---|
| **Sieve** | : | **01** | x | **0.75** | : | 0.75 |
| **Foot valve with sieve** | : | **01** | x | **1.75** | : | 1.75 |
| **90º curve** | : | **01** | x | **0.40** | : | 0.40 |
| **Gradual reduction** | : | **04** | x | **0.15** | : | 0.60 |
| **Dismantling joint** | : | **05** | x | **0.20** | : | 1.00 |
| **Connection, bilateral outlet** | : | **03** | x | **1.80** | : | 5.40 |
| **Connection, lateral outlet** | : | **02** | x | **1.30** | : | 2.60 |
| **Open Butterfly Valve (General)** | : | **05** | x | **0.30** | : | 1.50 |
| Suction Coefficient K | | | | | : | 14.00 |
| Suction head loss ( $h_s$ ) | | | | $K_s$ x ($V^2$/2g) | : | 0.12 m |

**PRESSURE LINES**

| PARTS | | Qtde | | KUNIT. | | KTOTAL |
|---|---|---|---|---|---|---|
| **Gradual enlargement** | : | **04** | x | **0.30** | : | 1.20 |
| **90º curve** | : | **02** | x | **0.40** | : | 0.80 |
| **22'30º curve** | : | **02** | x | **0.10** | : | 0.20 |
| **Dismantling joint** | : | **04** | x | **0.20** | : | 0.80 |
| **Connection, lateral outlet** | : | **04** | x | **1.30** | : | 5.20 |
| **Connection, bilateral outlet** | : | **01** | x | **1.80** | : | 1.80 |
| **Connection, direct passage** | : | **01** | x | **0.60** | : | 0.60 |
| **Check valve** | : | **04** | x | **2.50** | : | 10.00 |
| **Open Butterfly Valve (General)** | : | **04** | x | **0.30** | : | 1.20 |
| Pressure line coefficient K | | | | | : | 21.80 |
| Pressure line head loss ( $h_r$ ) | | | | $K_r$ x( $V^2$/2g) | : | 2.99 m |

Local head loss ( $h_f$ ) : $h_r$ + $h_s$ : 3.11 m

### *4.3. Total head loss*

Total head loss ( $H_J$ ) : J + $h_f$ : 5.13 m

## 5. Manometric Head Calculation

| | | |
|---|---|---|
| Total head loss ( $H_j$ ) | : | 5.13 m |
| Geometric Height ( Hg ) | : | 71.12 m |
| Manometric head ( $H_{man}$ ) : ( $H_g$ + $H_j$ ) | : | 76.25 m |

## 6. Piping Overpressure Analysis

| | | |
|---|---|---|
| Material Coefficient ( K ) | : | **18.0** |
| Piping Thickness ( E ) | : | **59.3 mm** |



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Piping Diameter ( D ) ------------------------------------------- : 881 mm

Speed ( C ) ---------------------------------------- : $\frac{9900}{(48,3 + K \times D / E)^{0,5}}$ : 557.06 m/s

Added Pressure ( $H_a$ ) ------------------------ : C x V / g : 93.10 m.c.a.

Maximum Demand Pressure ( $P_{máx.}$ ) : $H_a + H_{man.}$ : 169.34 m.c.a.

## 7. Pump Sizing

According to José Maria de Azevedo Netto, in practice, an allowance should be permitted for electric motors. The following additions are recommended:

| | |
|---|---|
| Para as pumps until 2 cv | 50 % |
| For pumps from 2 to 5 cv | 30 % |
| For pumps from 5 to 10 cv | 20 % |
| For pumps from 10 to 20 cv | 15 % |
| For pumps with more than 20 cv | 10 % |

Brazilian electric motors are normally manufactured with the following powers:
cv: 1/4; 1/3; 1/2; 3/4; 1; 1 1/2; 2; 3; 5; 6; 7 1/2; 10; 12; 15; 20; 25; 30; 35
cv: 40; 45; 50; 60; 80; 100; 125; 150; 200 e 250

The engines are made to order for higher powers. The manufacturer catalogs have electric motor powers manufactured differently from those specified above.

### *7.1. General Project*

Number of Pumps Expected ( N ) ------------------------------------ : **05**

Number of Pumps Operating Simultaneously ( n ) --------------- : **04**

Pump Yield ------------------------------------------------------------ : 80.00 %

Motor Yield ------------------------------------------------------------ : 90.00 %

Lifting Equipment Yield ( η ) --------------------------------------- : **72.00 %**

Pump Flow ( Q ) ------------------------------------------------------- : 250.00 L/s

Specific water weight ( γ ) -------------------------------------------- : 1.00 Kgf/L

Atmospheric pressure ( $p_a$ ) ------------------------------------------ : 0.95 $Kg/m^2$

Vapor pressure at 30ºC ( $p_v$ ) --------------------------------------- : 0.0458 $Kg/m^2$

Service Factor ( FS ) --------------------------------------------------- : **1.10**

Pump Power ( Po ) -------------------------- : $\frac{FS \times \gamma \times Q \times H_{man}}{n \times 75 \times \eta}$ : 97.04 CV

Pump Axis Rate ( $C_{EB}$ ) --------------------------------------- : **15.00 m**

Suction rate ( $C_S$ ) ------------------------------------------------ : 13.49 m

Suction local head loss ( $h_s$ ) -------------------------- : 0.12 m

Available NPSH ( $NPSH_d$ ) ------------------------ : $10 \times (p_a - p_v)/\gamma - h_f + (C_{EB} - C_S)$ : 10.43 m

### *7.2. Pump Characteristics Summary Board*

Adopted Power ( P ) -------------------------------------------------- : **400.00 CV**

Pump Flow ( Q ) ---------------------------------------------------- : 900.00 $m^3/h$

Manometric Head ( $H_{man}$ ) -------------------------------------------- : 76.25 m

### *7.3. Suggested Pumps*

Type of pump ------------------------------------------ : ***PUMPS HIGRA** : **R2-390**

Power ---------------------------------------------------------------------- : **400.00 CV**

Service flow ------------------------------------------------------------ : **900.00 $m^3/h$**

Manometric Head for Service Flow ------------------------------------ : **76.25 m**

Rotor Diameter ----------------------------------------------------------- : **330.0 mm**

Rotor Velocity ------------------------------------------------------------- : **1,750 rpm**



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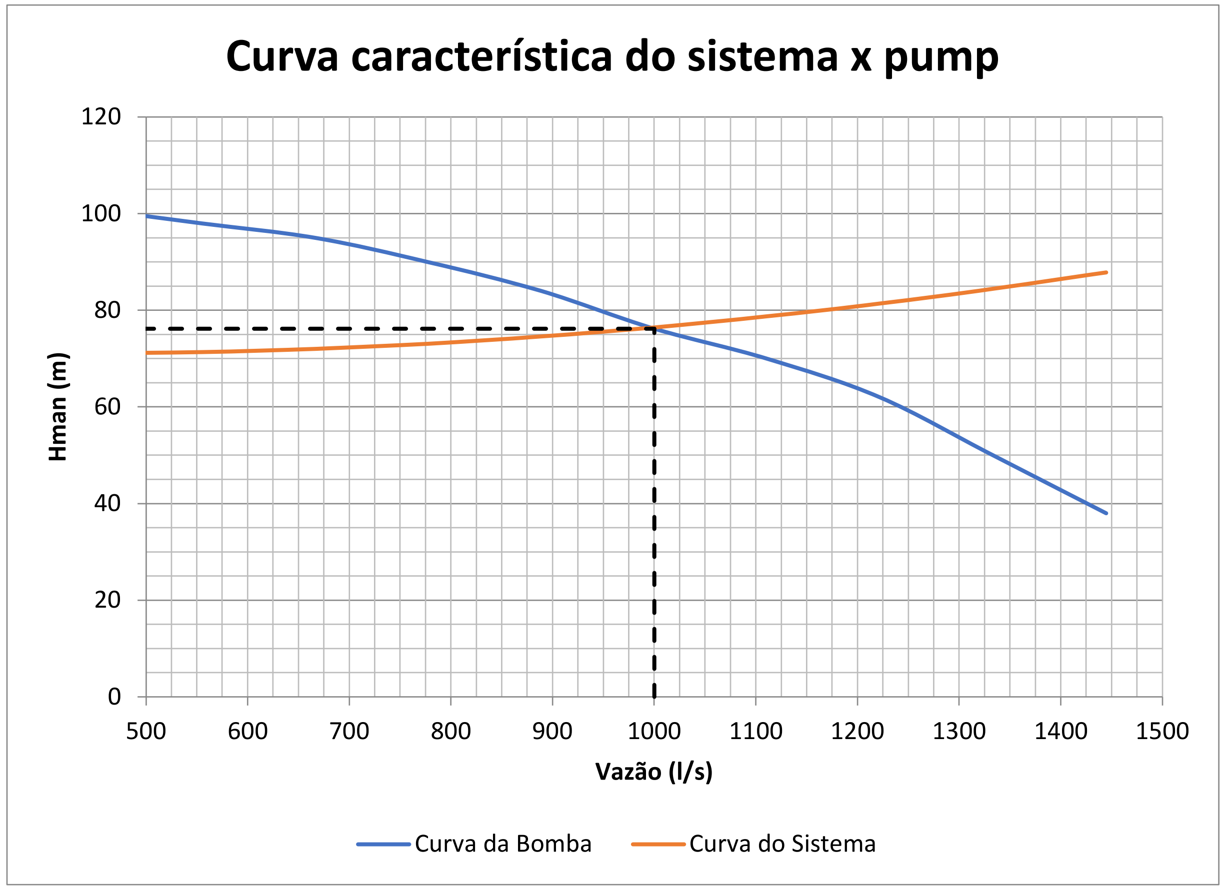
| | | |
|---|---|---|
| Required NPSH ($NPSH_r$) ----------------------------------------------- | : | **5.80 m** |
| Suction flanges--------------------------------------------------------------- | : | **1,000 mm** |
| Pressure Flanges --------------------------------------------------------- | : | **1,000 mm** |

**** Adopt suggested pump or similar***

### *7.4. Characteristic System vs. Pump Curve*






5.- SISTEMAS AUXILIARES





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## Planta de Fortaleza

### 5.- SISTEMAS AUXILIARES

5.1.- BOMBAS E TANQUES DE LIMPEZA QUÍMICA

| | | |
|---|---|---|
| o equipamento está desenhado para lavar: | Toda a linha | |
| Número de tubos a lavar simultaneamente: | 226 | Uds. |
| vazão por tubo de pressão | 5 | m3/h |
| Perda de carga máxima no Tubo de Pressão | 3,45 | bars |
| Volume adicional nas tubulações de conexão | 41,9 | m3 |
| Número de bombas de lavagem em operação | 2 | Uds. |
| Número de bombas de lavagem em reserva: | 0 | Uds. |
| vazão da bomba: | 565,00 | m3/h |
| Volume para encher antes de retornar ao tanque: | 74,93 | m3 |
| Volume mínimo de seguridade no tanque: | 29,7 | m3 |
| Volume minimo do tanque de lavagem | 105 | m3 |
| Volume do tanque selecionado: | 110 | m3 |
| Tempo de retenção | 5,8 | minutos |
| Tempo estimado entre duas limpezas químicas: | 51 | dias |
| Tempo de aquecimento | 8,0 | horas |
| Potencia total das resistencias de aquecimento | 208 | Kw |

## Planta de Fortaleza

### 5.- SISTEMAS AUXILIARES

5.2.- FILTROS DE CARTUCHO

| | | |
|---|---|---|
| vazão de agua de lavagem a filtrar: | 1.130,00 | m3/h |
| Tipo de filtros | Cartucho | |
| Posição dos filtros | Vertical | |
| Velocidade máxima em conexões | 1,8 | m/seg |
| Tipo de cartucho | PP-1 | |
| Modelo de cartucho: | BOBINADO-1 | |
| Material del cartucho: | POLIPROPIL. | |
| Número de cartuchos por filtro: | 348 | Uds. |
| Poder de corte do cartucho: | 10 | micras absol |
| Eficiencia da filtração | 99,600% | |
| Beta ratio: | 5.000 | |
| Vazão máximo por cartucho: | 3,255 | m3/h |
| Vazão real por cartucho: | 3,25 | m3/h |
| Diametro del cartucho: | 61 | mm. |
| Comprimento do cartucho | 1.270 | mm |
| Superficie filtrante do cartucho | 0,2425 | m2 |
| Perda de carga | 1,6 | m.c.a. |
| Perda de carga maxima admissivel | 2 | bars |
| Perda de carga maxima desenho | 15 | m.c.a. |
| Número de filtros: | 1 | Uds. |
| Diâmetro interno do filtro | 1.800 | mm. |
| Altura do corpo do filtro: | 3.038 | mm. |
| Pressão de desenho do filtro: | 6 | bars |
| Velocidade de filtração em operação | 13,39 | m/h |
| Separação entre cartuchos: | 15 | mm. |

Source: GS Inima



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## Planta de Fortaleza

### 5.- SISTEMAS AUXILIARES

5.3.- DEPÓSITO DE AGUA DE DESLOCAMENTO

| | | |
|---|---|---|
| Número de linhas a deslocar | 1 | Uds. |
| Número de depósitos: | 1 | Uds. |
| Volume de cada depósito: | 200 | m3 |
| qualidade da agua armazenada | água permeada | |

Source: GS Inima

## Planta de Fortaleza

### 5.- SISTEMAS AUXILIARES

5.4.- BOMBEAMENTO DE DESLOCAMENTO DA SALMORA

| | | |
|---|---|---|
| Número bombas de deslocamento em operac.: | 1 | Uds. |
| Número bombas de deslocamento em reserv.: | 0 | Uds. |
| vazão de cada bomba: | 565,00 | m3/h |
| Pressão de descarga | 6,52 | bars |
| Volume de salmora a deslocar: | 112,40 | m3 |
| Tempo para realizar o deslocamento | 11,9 | minutos |

Source: GS Inima



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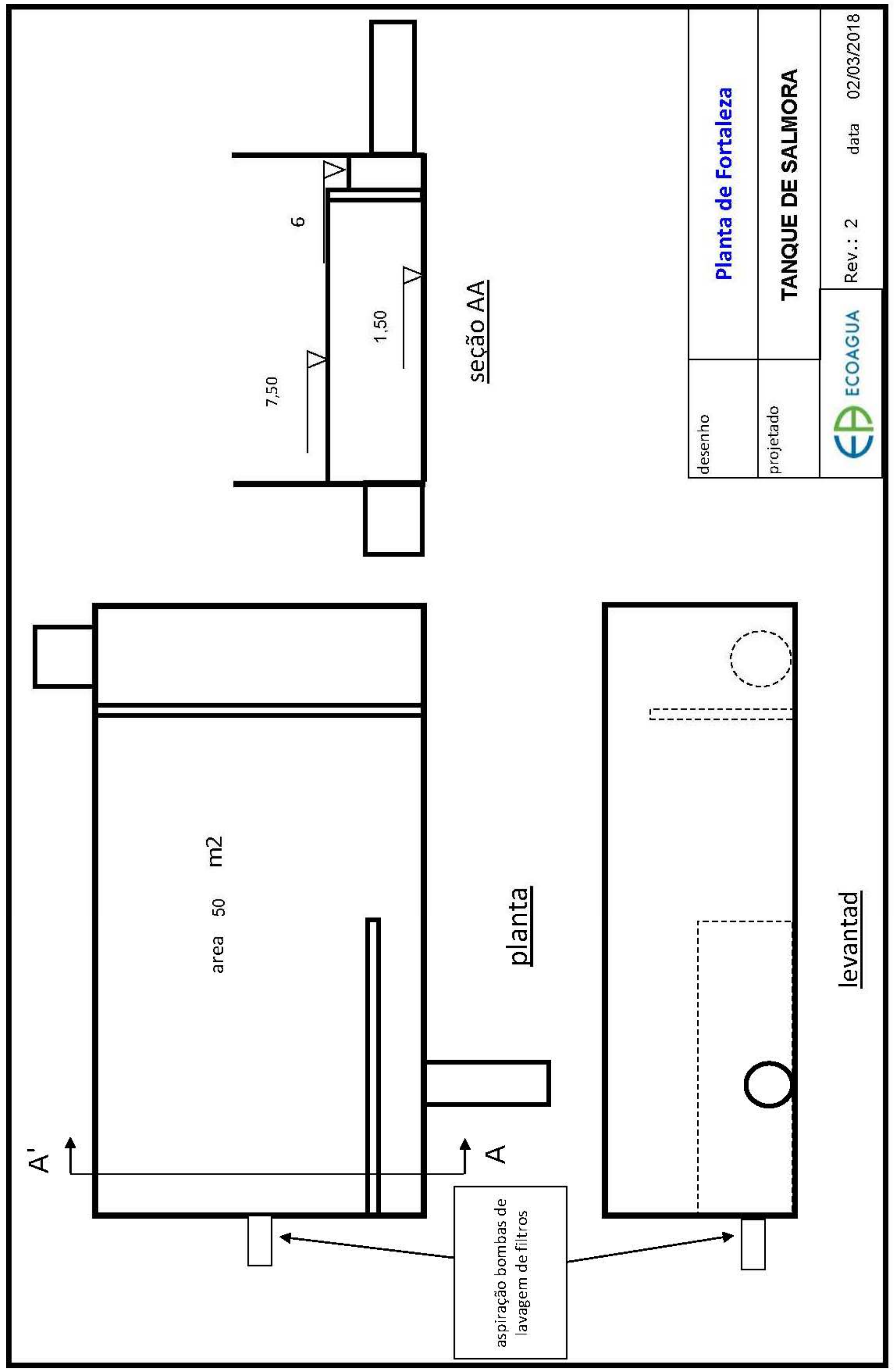
## Planta de Fortaleza

### 5.- SISTEMAS AUXILIARES

5.5.- TANQUE DE SALMORA

| | | |
|---|---|---|
| vazão total de salmora ao tanque: | 4.413 | m3/h |
| Vazão total de agua para lavagem dos filtros: | 3.828 | m3/h |
| Número mínimo de linhas necessárias em operação | 4 | Uds. |
| | | |
| Cota máxima do vertedouro da salmora: | 7,50 | m.s.n.m. |
| Volume do tanque de salmora | 300 | m3 |
| Diametro da tubulação de aspiração bombas lavagem | 800 | mm. |
| Área da planta do tanque: | 50 | m2 |
| Cota do fundo do tanque de salmora: | 1,50 | m.s.n.m. |
| Diametro de coletor de salmora de SIP a tanque: | 1100 | mm. |
| Velocidade no coletor de salmora: | 1,29 | m/s |
| Cota lámina de agua para descarga por gravedad: | 6 | m.s.n.m. |
| Drenajes y vaciados bombeados a sección de descarga: | SI | |

Source: GS Inima




Source: GS Inima



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## Planta de Fortaleza

### CALCULOS HIDRAULICOS

5.1.- BOMBAS DE LIMPEZA QUÍMICA

| | | |
|---|---|---|
| Cota geometrica do nivel do liquido no tanque (min): | 6,25 | m |
| Perda de carga máxima nas membranas: | 3,45 | bars |
| Altura cilindrica do tanque de limpeza: | 4,0 | m |
| Cota geométrica da aspiração das bombas: | 5,525 | m |
| Cota geométrica ponto mais alto da estrutura do 1º passo: | 14,5 | m |
| Cota geométrica de entrada ao tanque de limpeza: | 9,0 | m |
| vazão de la bomba de limpeza: | 565 | m3/h |
| vazão de limpeza por fila estrutura | 44,4 | m3/h |
| vazão de total de limpeza a estrutura | 1.130 | m3/h |

| | | |
|---|---|---|
| Tipo de fluido a bombear: | Solução química | |
| Temperatura do fluido bombeado | 27 | ºC |
| Densidade do fluido bombeado | 1,0267 | Kg/l |
| Viscosidade do fluido bombeado | 0,8538 | cp. |
| Fator de segurança perda atrtito | 20 | % |

| | Tubulação | | | Vazão | Velocidade | Número de Reynolds | Perda de carga unitária | Comprimento equivalente | Outras perdas de carga | Perda de carga total | Perda por seção |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DN | D interior | Material | | | | | | | | |
| | (mm.) | (mm.) | ------------ | (m3/h) | (m/s) | ---------- | (m.c.a./Km.) | (m) | (m.c.a.) | (m.c.a.) | (m.c.a.) |
| Impulsão da bomba | 450,0 | 450,0 | PRFV | 1.130,0 | 1,97 | 1.068.017 | 7,19 | 3 | 0,00 | 0,0 | 0,03 |
| | 450,0 | 450,0 | PRFV | 565,0 | 0,99 | 534.008 | 1,99 | 1 | 0,00 | 0,0 | |
| Sessão da impulsão da bomba | 350,0 | 350,0 | PRFV | 565,0 | 1,63 | 686.582 | 6,77 | 81 | 0,01 | 0,6 | 17,0 |
| | 450,0 | 450,0 | PRFV | 1.130,0 | 1,97 | 1.068.017 | 7,19 | 67 | 0,00 | 0,5 | |
| | 450,0 | 450,0 | PRFV | 1.130,0 | 1,97 | 1.068.017 | 7,19 | 141 | 0,39 | 1,4 | |
| | 350,0 | 333,4 | 904hMo | 565,0 | 1,80 | 720.832 | 13,95 | 28 | 0,68 | 1,1 | |
| | 90,0 | 77,9 | 904hMo | 25,0 | 1,46 | 136.442 | 51,44 | 8 | 0,61 | 1,0 | |
| | 40,0 | 35,1 | 904hMo | 5,0 | 1,44 | 60.673 | 127,93 | 5 | 0,54 | 1,1 | |
| | 40,0 | 35,1 | 904hMo | 5,0 | 1,44 | 60.673 | 127,93 | 3 | 0,80 | 1,2 | |
| | 90,0 | 77,9 | 904hMo | 25,0 | 1,46 | 136.442 | 51,44 | 11 | 0,77 | 1,4 | |
| | 250,0 | 254,5 | 904hMo | 565,0 | 3,09 | 944.219 | 51,95 | 33 | 2,90 | 4,6 | |
| | 450,0 | 450,0 | PRFV | 1.130,0 | 1,97 | 1.068.017 | 7,19 | 141 | 0,39 | 1,4 | |

| SESSÃO DA IMPULSÃO DA BOMBA | | |
|---|---|---|
| Perdas de carga nos filtros do cartucho | 5,82 | m.c.a. |
| Altura geométrica de impulsão | 8,47 | m.c.a. |
| Perda de carga nas tubulações de impulsão bomba | 17,03 | m.c.a. |
| T.D.H. a vazão normal da bomba: | 64,06 | m.c.l. |
| Pressão de descarga de bomba a vazão normal: | 6,52 | bars |
| Pressão na aspiração | 0,74 | m.c.a. |
| Tensão de vapor a tempertaura do mar | 0,37 | m.c.a. |
| N.P.S.H. disponivel | 10,43 | m.c.l. |

| IMPULSÃO DA BOMBA | | |
|---|---|---|
| Perda de carga nas tubulações de aspiração | 0,0 | m.c.a. |
| Pressão de saida da membranas | 10,06 | m.c.a. |
| Número de rodetes da bomba: | 1 | Uds. |
| Velocidade de giro: | 1500 | r.p.m. |
| Velocidade específica: | 26,24 | |
| NPSH recomendado: | 6,21 | m.c.l. |

Source: GS Inima



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## Planta de Fortaleza

### 5.1.- BOMBAS DE LIMPEZA QUÍMICA: CÁLCULO DO COMPRIMENTO EQUIVALENTES

| | IMPULSÃO DA BOMBA | | SESSÃO DA IMPULSÃO DA BOMBA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIAMETRO | 450 | 450 | 350 | 450 | 450 | 350 | 90 | 40 | 40 | 90 | 250 | 450 |
| SERVIÇO | COLETOR SAIDA TANQUE ARMAZ | ASPIRAÇÃO DA BOMBA | SAIDA DE IMPULSÃO BOMBA | ENTRADA/SAIDA DE FILTROS CARTUCHO | COLETOR DE IMPULSÃO DA ESTRUTURA | COLUNA DE DISTRIBUIÇÃO DA ESTRUTURA | TUB. DISTRIBUC HORIZON | ENTRADA DO TUBO DE PRESSÃO | SAIDA DO TUBO DE PRESSÃO | TUB. HORIZON COLETA REJEITO | COLUNA DE SAIDA DA ESTRUTURA | COLETOR DE RETORNO AO TANQUE |
| COMPRIMENTO RETO | 3 | 1 | 4 | 4 | 100 | 10 | 6 | 1 | 1 | 6 | 10 | 100 |
| CURVA 90º (RAIO COMPRIDO) | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| CURVA 90º (STANDARD) | | | 1 | 2 | 3 | 1 | 0 | 1 | 1 | 0 | 1 | 3 |
| CURVA 45º (STANDARD) | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| CURVA 45º (RAIO CURTO) | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| TE | | | | | | 1 | 1 | 0 | 1 | 0 | 0 | |
| TE | | | | | | 0 | 0 | 1 | 0 | 1 | 1 | |
| VÁLVULA BORBOLETA | | | 1 | 2 | | 0 | 0 | 0 | 0 | 0 | 0 | |
| V. RETENÇÃO | | | 1 | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| V. GLOBO | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| V. COMPOERTA | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| V. ANGULO | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| COMPRIMENTO EQUIVALENTE | 3 | 1 | 81 | 67 | 140,5 | 27,5 | 7,8 | 4,6 | 3 | 11,4 | 32,5 | 140,5 |
| ENTRADA | | | | | | 0 | 1 | 0 | 1 | 0 | 0 | |
| SAIDA | | | | | | 0 | 0 | 1 | 0 | 1 | 0 | |
| REDUÇÃO | | 400 | | | | 180 | 0 | 0 | 0 | 0 | 200 | |
| | | | | | | 140 | 0 | 0 | 0 | 0 | 100 | |
| | | | | | | 100 | 0 | 0 | 0 | 0 | 0 | |
| ALARGAMENTO | | | 300 | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| VÁLVULAS DE MACHO | | | | | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| SOMA DO COEFICIENTE K | 0,0 | 0,0 | 0,1 | 0,0 | 1,9 | 4,0 | 5,5 | 5,0 | 7,4 | 6,9 | 5,8 | 1,9 |

Source: GS Inima



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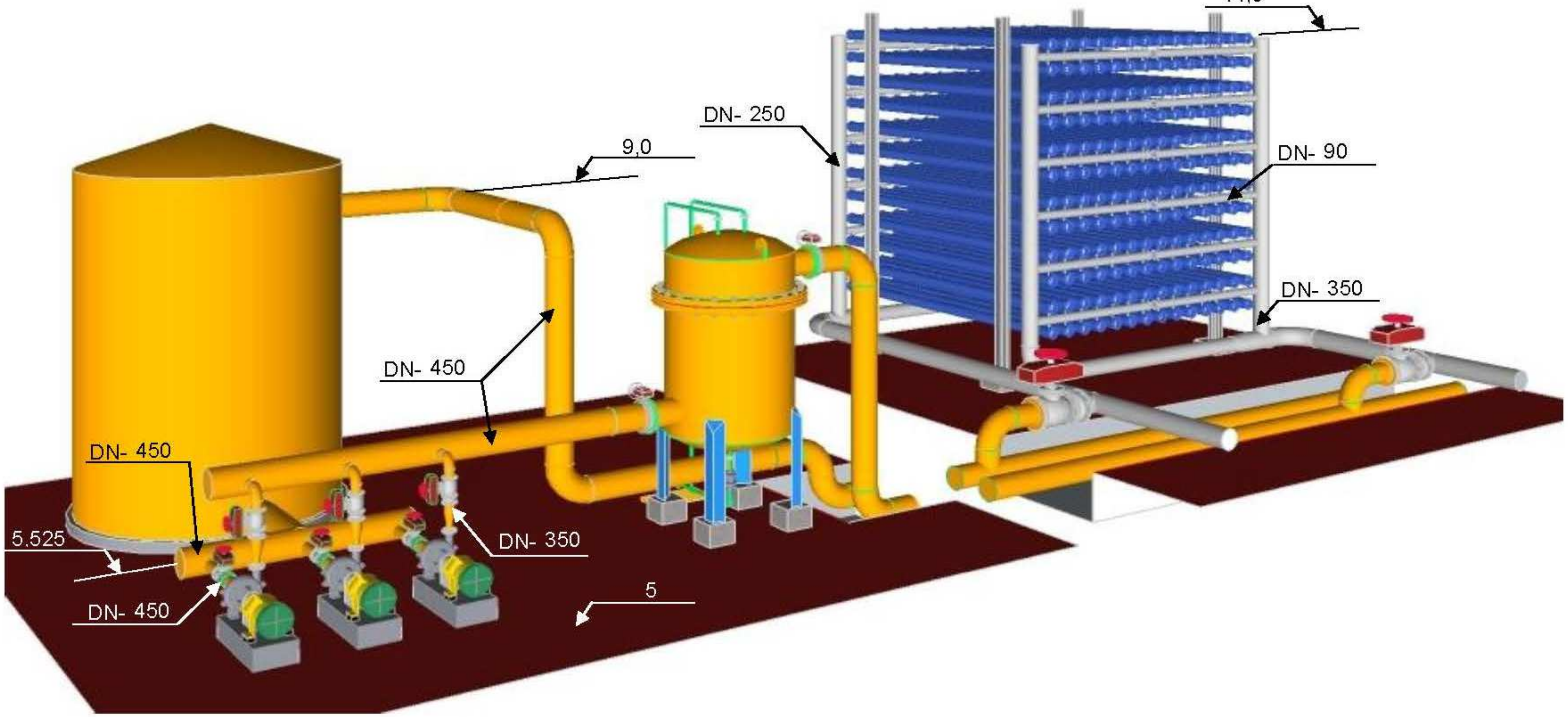
## Planta de Fortaleza




| Fortaleza |
| --- |
| CALCULOS HIDRAULICOS |
| BOMBAS DE LIMPEZA QUÍMICA |

Source: GS Inima



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## Planta de Fortaleza

| COMPOSIÇÃO DA SALMORA A SAIDA DE MEMBRANAS | | | | | |
|---|---|---|---|---|---|
| **ANÁLISE FISICO-QUIMICO** | | | | | |
| TURBIDEZ | | U.N.F. | PH | 7,23 | |
| COR | | Pt-Co | CONDUTIBILIDADE A | 98.196,41 | µmhos/cm. |
| ODOR | | | T.D.S. | 72.681,69 | mg/L |
| ASPECTO | | | ALCALINIDADE | 226,48 | ppm CO3Ca |
| TEMPERATURA | 27 | ºC | DUREZAE | 11.955,30 | ppm CO3Ca |
| **COMPOSIÇÃO IONICA** | | | | | |
| **ELEMENTO** | **mg/L** | **meq/l** | **ELEMENTO** | **mg/L** | **meq/l** |
| Ca++ | 941,32 | 46,97 | SO4= | 7.779,03 | 161,96 |
| Mg++ | 2.333,02 | 191,92 | Cl- | 38.002,38 | 1.071,91 |
| Na+ | 22.523,16 | 979,65 | CO3H- | 262,18 | 4,30 |
| K+ | 780,17 | 19,95 | F- | 0,56 | 0,03 |
| Ba++ | 0,04 | 0,00 | Br- | 0,00 | 0,00 |
| Sr++ | 9,52 | 0,22 | I- | 0,00 | 0,00 |
| Fe++ | 0,00 | 0,00 | NO2- | 0,00 | 0,00 |
| NH4+ | 0,56 | 0,03 | NO3- | 20,00 | 0,32 |
| Ag+ | 0,00 | 0,00 | CO3= | 6,86 | 0,23 |
| Mn++ | 0,00 | 0,00 | PO4= | 0,00 | 0,00 |
| Zn++ | 0,00 | 0,00 | S= | 0,00 | 0,00 |
| Cu++ | 0,00 | 0,00 | SiO2 (coloidal) | 0,07 | 0,00 |
| Al+++ | 0,00 | 0,00 | SiO2 (soluble) | 15,33 | 0,26 |
| Fe+++ | 0,00 | 0,00 | CO2 | 8,02 | 0,18 |
| H+ | | 0,00 | OH- | | 0,00 |
| **TOTAL** | **26.587,80** | **1.238,75** | **TOTAL** | **46.086,34** | **1.238,75** |

| OUTRAS DETERMINAÇÕES | | | |
|---|---|---|---|
| SUBSTÂNCIAS TOXICAS | mg/L | Matéria orgânica e outros | mg/L |
| Arsênio | 0,00 | DBO5 | 0,08 |
| Cádmo | 0,00 | DQO | 0,19 |
| Bário | 7,55 | Nitrogêno proteico | 0,00 |
| Mercurio | 0,00 | Compostos fenólicose | 0,00 |
| Chumbo | 0,00 | Detergentes | 0,00 |
| Selênio | 0,00 | Oleos e graxas | 0,00 |
| Cromo total | 0,00 | Hidrocarbonetos | 0,00 |
| Cromo | 0,00 | Sólidos em suspensão | 0,38 |

## Planta de Fortaleza

### PROPRIEDADES DA SALMORA

| | | |
|---|---|---|
| DENSIDADE | 1,051 | Kg/l |
| VISCOSIDADE CINEMATICA | 0,010 | stokes |
| VISCOSIDADE DINAMICA | 1,007 | cp. |
| PRESSÃO DO VAPOR | 0,015 | bars |
| PONTO DE EBULIÇÃO | 0,762 | ºC |
| CALOR ESPECIFICO | 0,926 | Kcal/KgxºC |
| CONDUTIBILIDADE TÉRMICA | 569,6 | mW/mxºC |
| ENTALPIA | 24,53 | Kcal/Kg |
| INDICE DE LANGELIER: | 0,88 | |
| INDICE DE STIFF & DAVIS: | -0,19 | corrosiva |
| INDICE DE SAL | 89,64 | |
| MAXIMO OXIGÊNIO DISSOLVIDO | 4,4 | ppm. |
| MAXIMO NITROGÊNIO DISSOLVIDO | 6,0 | ppm. |
| CO2 DISSOLVIDO | 8,02 | ppm. |
| FORÇA IONICA DA ÁGUA | 1,43859 | |
| PRESSÃO OSMÓTICA DA ÁGUA | 55,87 | bars |

### CALCULO DE INCRUSTAÇÕES

há que dosar um dispersante, se não haver incrustações

Source: GS Inima



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## Planta de Fortaleza

**SALMORA DE DESCARGA**

| ANÁLISE FISICO-QUIMICO | | | | | |
|---|---|---|---|---|---|
| TURBIDEZ | | U.N.F. | PH | 7,24 | |
| COR | | Pt-Co | CONDUTIBILIDADE A | 96.098,49 | µmhos/cm. |
| ODOR | | | T.D.S. | 70.687,35 | mg/L |
| ASPECTO | | | ALCALINIDADE | 220,25 | ppm CO3Ca |
| TEMPERATURA | 27 | ºC | DUREZAE | 11.628,31 | ppm CO3Ca |

| COMPOSIÇÃO IONICA | | | | | |
|---|---|---|---|---|---|
| **ELEMENTO** | **mg/L** | **meq/l** | **ELEMENTO** | **mg/L** | **meq/l** |
| Ca++ | 915,56 | 45,69 | SO4= | 7.566,27 | 157,53 |
| Mg++ | 2.269,22 | 186,68 | Cl- | 36.959,23 | 1.042,49 |
| Na+ | 21.904,75 | 952,75 | CO3H- | 254,78 | 4,18 |
| K+ | 758,73 | 19,40 | F- | 0,54 | 0,03 |
| Ba++ | 0,04 | 0,00 | Br- | 0,00 | 0,00 |
| Sr++ | 9,26 | 0,21 | I- | 0,00 | 0,00 |
| Fe++ | 0,00 | 0,00 | NO2- | 0,00 | 0,00 |
| NH4+ | 0,55 | 0,03 | NO3- | 19,45 | 0,31 |
| Ag+ | 0,00 | 0,00 | CO3= | 6,77 | 0,23 |
| Mn++ | 0,00 | 0,00 | PO4= | 0,00 | 0,00 |
| Zn++ | 0,00 | 0,00 | S= | 0,00 | 0,00 |
| Cu++ | 0,00 | 0,00 | SiO2 (coloidal) | 0,07 | 0,00 |
| Al+++ | 0,00 | 0,00 | SiO2 (soluble) | 14,91 | 0,25 |
| Fe+++ | 0,00 | 0,00 | CO2 | 7,73 | 0,18 |
| H+ | | 0,00 | OH- | | 0,00 |
| **TOTAL** | **25.858,10** | **1.204,76** | **TOTAL** | **44.821,95** | **1.204,76** |

| OUTRAS DETERMINAÇÕES | | | |
|---|---|---|---|
| SUBSTÂNCIAS TOXICAS | mg/L | Matéria orgânica e outros | mg/L |
| Arsênio | 0,00 | DBO5 | 0,07 |
| Cádmo | 0,00 | DQO | 0,17 |
| Bário | 7,29 | Nitrogêno proteico | 0,00 |
| Mercurio | 0,00 | Compostos fenólicose | 0,00 |
| Chumbo | 0,00 | Detergentes | 0,00 |
| Selênio | 0,00 | Oleos e graxas | 0,00 |
| Cromo total | 0,00 | Hidrocarbonetos | 0,00 |
| Cromo | 0,00 | Sólidos em suspensão | 0,33 |

## Planta de Fortaleza

PROPRIEDADES DA SALMORA

| | | |
|---|---|---|
| DENSIDADE | 1,049 | Kg/l |
| VISCOSIDADE CINEMATICA | 0,010 | stokes |
| VISCOSIDADE DINAMICA | 1,001 | cp. |
| PRESSÃO DO VAPOR | 0,015 | bars |
| PONTO DE EBULIÇÃO | 0,737 | ºC |
| CALOR ESPECIFICO | 0,928 | Kcal/KgxºC |
| CONDUTIBILIDADE TÉRMICA | 569,9 | mW/mxºC |
| ENTALPIA | 24,60 | Kcal/Kg |
| INDICE DE LANGELIER: | 0,87 | |
| INDICE DE STIFF & DAVIS: | -0,20 | corrosiva |
| INDICE DE SAL | 88,39 | |
| MAXIMO OXIGÊNIO DISSOLVIDO | 4,5 | ppm. |
| MAXIMO NITROGÊNIO DISSOLVIDO | 6,2 | ppm. |
| CO2 DISSOLVIDO | 7,73 | ppm. |
| FORÇA IONICA DA ÁGUA | 1,39914 | |
| PRESSÃO OSMÓTICA DA ÁGUA | 61,22 | bars |

CALCULO DE INCRUSTAÇÕES

há que dosar um dispersante, se não haver incrustações

Source: GS Inima



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## 6.- BALANÇOS E DIAGRAMAS



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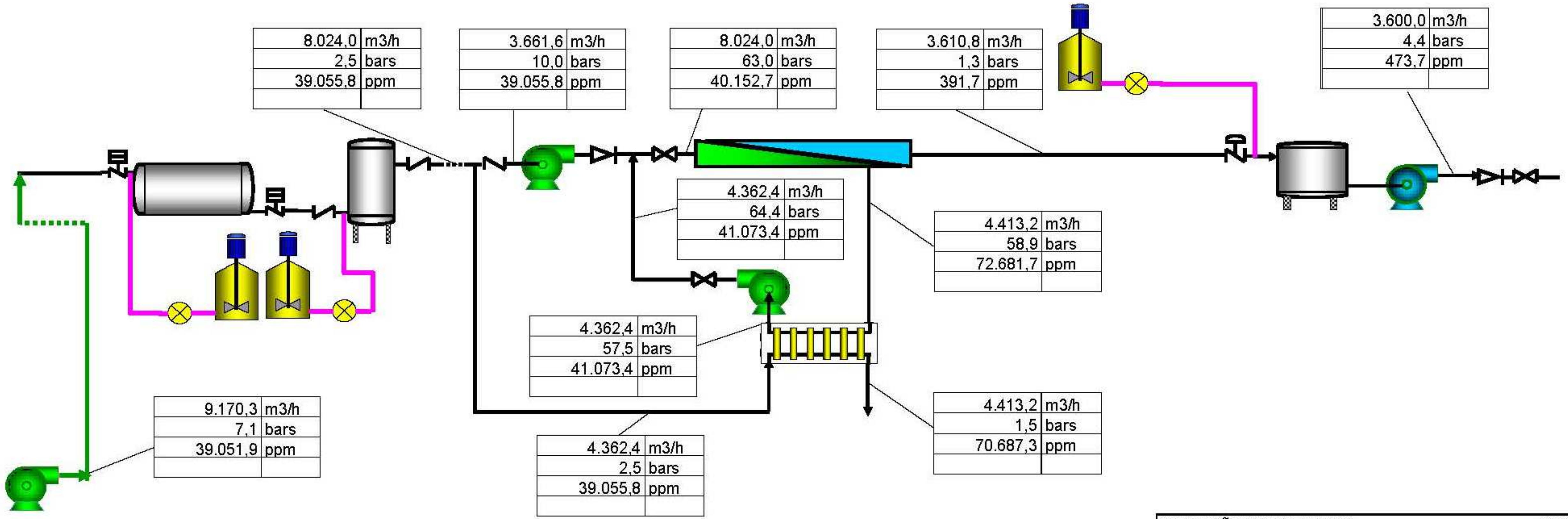


| | |
|---|---|
| CONVERSÃO GLOBAL PLANTA | 39,26% |
| CONVERSÃO REAL PLANTA: | 39,38% |
| CONVERSÃO DAS MEMBRANAS | 45,00% |

| | |
|---|---|
| NÚMERO DE LINHAS | 4 |

| BALANÇO DE ENERGIA | POTENCIA Kw | ENERGIA ANUAL Kwh/ano |
|---|---|---|
| Bombas de agua do mar | 560,45 | 18.831.129 |
| Bombas de alta pressão | 1.674,62 | 56.267.079 |
| Bombas de recirculação | 1.097,15 | 9.216.100 |
| Bomba Booster Para Bomba De Alta Pressão | 1.107,28 | 9.301.125 |
| Bombas de produto | 538,68 | 4.524.936 |
| Outros consumos e perdas | | 6.452.511,93 |
| TOTAL | | 104.592.881 |
| CONSUMO ESPECÍFICO DE ENERGÍA (Kwh/m3) | | 3,46 |

| engenharia Consultiva | PLANTA DESSALINIZAÇÃO DE FORTALEZA | |
|---|---|---|
| | 02-Mar-18 | **balanço geral** |
| | Rev: 2 | **Base** |

Source: GS Inima

## 14.4. List of Electrical Equipment



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Cagece Companhia de Água e Esgoto do Ceará

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## LISTA DE BOMBAS E SOPRADORES

**SOLUÇÃO: Base** **FOLHA**

| Nº ITEM | DESCRIÇÃO | NÚMERO UNIDADE TOTAL | NÚMERO UNIDADE OPERAÇÃO | VAZÃO | PRESSÃO ASPIRAÇÃO | PRESSÃO IMPLUSÃO | DENSIDADE | T.D.H. | BOMBA RENDIMENTO | BOMBA POTÊNCIA ABSORVIDA | MOTOR RENDIMENTO | MOTOR POTÊNCIA ABSORVIDA | POTÊNCIA NOM. MOTOR | NOTAS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | m3/h | bars | bars | kg/l | m.c.l. | % | kW | % | kW | kW | |
| 1.01 | BOMBA AGUA DO MAR NA CAPTAÇÃO | 5 | 4 | 2.292,57 | 0,25 | 7,06 | 1,0254 | 67,73 | 83,8% | 517,75 | 97,00% | 560,45 | 710 | |
| 1.03 | MOTO VALVULAS DE DESCARGA | 5 | 4 | | | | | | | | | 0,55 | 0,55 | |
| 3.01 | B. BOOSTER ALIMENTAÇÃO B.A.P. | 4 | 4 | 915,40 | 2,50 | 10,88 | 1,03 | 83,37 | 84,0% | 253,88 | 96,30% | 276,82 | 315 | |
| 3.02 | MOTO-VÁLVULA DE ASPIRAÇÃO E DESCARGA | 8 | 8 | | | | | | | | | 0,55 | 0,55 | |
| 4.01 | MOTOBOMBA DE ALTA PRESSÃO | 4 | 4 | 915,40 | 10,00 | 64,55 | 1,03 | 542,56 | 85,0% | 1.632,75 | 97,50% | 1.674,62 | 1800 | |
| 4.02 | MOTO-VÁLVULA DE ASPIRAÇÃO E DESCARGA | 8 | 8 | | | | | | | | | 0,55 | 0,55 | |
| 4.03 | BOMBAS DE RECIRCULAÇÃO | 4 | 4 | 1.090,60 | 57,50 | 64,39 | 1,03 | 68,51 | 83,0% | 251,56 | 96,30% | 274,29 | 315 | |
| 4.04 | MOTO-VÁLVULA DE ASPIRAÇÃO E DESCARGA | 8 | 8 | | | | | | | | | 0,55 | 0,55 | |
| 7.01 | POTÊNCIA DE DESCARGA DO PRODUTO | 5 | 4 | 900,00 | -0,01 | 4,37 | 0,9968 | 44,86 | 85,0% | 129,01 | 95,80% | 134,67 | 160 | |
| 8.01 | MOTOBOMBA DE LAVADO DE FILTROS | 3 | 2 | 1.914,00 | 0,05 | 2,27 | 1,0494 | 21,60 | 80,0% | 147,77 | 96,20% | 153,61 | 200 | |
| 8.02 | SOPRADORES LAVAGEM DE FILTROS | 3 | 2 | 2.210,74 | -0,10 | 0,60 | 0,0013 | 5.534,88 | 70,0% | 45,46 | 94,00% | 48,36 | 75 | |
| 9.01 | POTÊNCIA QUIMICA | 2 | 2 | 565,0 | 0,07 | 6,52 | 1,0267 | 64,06 | 80,0% | 126,58 | 95,80% | 132,13 | 160 | |
| 9.03 | MOTOBOMBA DE DESLOCAMENTO | 1 | 1 | 565,00 | 0,07 | 6,52 | 1,0267 | 64,06 | 80,0% | 126,58 | 95,80% | 132,13 | 160 | |
| 9.05 | RESISTÊNCIA DE AQUECIMENTO L.Q. | 1 | 1 | | | | | | | | | 207,85 | 207,85 | |
| 11.02 | HIDROCOMPRESSORES ÁGUA DE SEWRVIÇO | 2 | 1 | 10 | 0 | 6 | 0,99 | 61,82 | 77,0% | 2,17 | 81,50% | 2,66 | 4 | |
| 11.03 | EXTRATOR SILENCIADOR SOPR. F.A. | 3 | 2 | | | | | | | | | 1,10 | 1,1 | |

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Cagece Companhia de Água e Esgoto do Ceará

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## LISTA DE BOMBAS E SOPRADORES

**SOLUÇÃO: Base** **FOLHA**

| Nº ITEM | DESCRIÇÃO | NÚMERO UNIDADE | | VAZÃO | PRESSÃO ASPIRAÇÃO | PRESSÃO IMPLUSÃO | DENSIDADE | T.D.H. | BOMBA | | MOTOR | | POTÊNCIA NOM. MOTOR | NOTAS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TOTAL | OPERAÇÃO | | | | | | RENDIMENTO | POTÊNCIA ABSORVID | RENDIMENTO | POTÊNCIA ABSORVID | | |
| | | | | m3/h | bars | bars | kg/l | m.c.l. | % | kW | % | kW | kW | |
| 12.1 | BOMBA DE DOSIFICAÇÃO ACIDO SULFURICO | 3 | 2 | 0,04 | 0,10 | 8,00 | 1,84 | 43,79 | 65,0% | 0,01 | 66,00% | 0,02 | 0,37 | |
| 12.2 | BOMBA DE DOSIFICAÇÃO HIPOCLORITO SÓDICO | 3 | 2 | 0,50 | 0,10 | 8,00 | 1,24 | 64,98 | 65,0% | 0,17 | 66,00% | 0,26 | 0,37 | |
| 12.3 | BOMBA DE DOSIFICAÇÃO METABISULFITO SÓDICO | 3 | 2 | 0,15 | 0,10 | 8,00 | 1,1 | 73,25 | 65,0% | 0,05 | 66,00% | 0,08 | 0,37 | |
| 12.4 | BOMBA DE DOSIFICAÇÃO CLORETO FERRICO | 3 | 2 | 0,06 | 0,10 | 8,00 | 1,417 | 56,87 | 65,0% | 0,02 | 66,00% | 0,03 | 0,37 | |
| 12.5 | BOMBA DE DOSIFICAÇÃO DISPERSANTE | 3 | 2 | 0,01 | 0,10 | 8,00 | 2 | 40,29 | 65,0% | 0,00 | 66,00% | 0,01 | 0,37 | |
| 12.9 | BOMBA DE DOSIFICAÇÃO HIDROXIDO DE CALCIO | 3 | 2 | 0,00 | 0,10 | 120,00 | 1,0012508 | 1.221,45 | 65,0% | 0,01 | 66,00% | 0,01 | 0,37 | |
| 12.10 | BOMBA DE DOSIFICAÇÃO FLUORSILICATO DE SODIO | 3 | 2 | 0,04 | 0,10 | 8,00 | 1,1 | 73,25 | 65,0% | 0,01 | 66,00% | 0,02 | 0,37 | |
| 12.11 | BOMBA DE DOSIFICAÇÃO HIPOCLORITO DE SODIO | 3 | 2 | 0,03 | 0,10 | 8,00 | 1,24 | 64,98 | 65,0% | 0,01 | 66,00% | 0,02 | 0,37 | |
| 12.22 | BOMBA TRANSFERÊNCIA DE ACIDO SULFURICO | 1 | 1 | 60 | 0 | 1,5 | 1,84 | 8,32 | 67,0% | 3,73 | 86,00% | 4,34 | 5,5 | |
| 12.23 | BOMBA TRANSFERÊNCIA DE HIPOCLORITO SÓDICO | 2 | 2 | 0 | 0 | 0 | 1,24 | 0,00 | 67,0% | 0,00 | 66,00% | 0,00 | 0,37 | |
| 12.24 | AGITADOR DE METABISULFITO SODICO | 1 | 1 | | | | | | | | | 1,50 | 1,5 | |
| 12.25 | BOMBA TRANSFERÊNCIA DE CLORETO FÉRRICO | 1 | 1 | 60 | 0 | 1,5 | 1,42 | 10,80 | 67,0% | 3,73 | 86,00% | 4,34 | 5,5 | |
| 12.26 | AGITADOR DE DISPERSANTE | 2 | 2 | | | | | | | | | 0,55 | 0,55 | |
| 12.27 | EVAPORADOR DE ANHIDRIDO CARBONICO | 1 | 1 | | | | | | | | | 15,00 | 15 | |
| 12.28 | SISTEMA DE LLENADO DE LOS SILOS HIDROXIDO CA | 1 | 1 | | | | | | | | | 1,50 | 1,5 | |
| 12.29 | AGITADOR DE FLUOR | 1 | 1 | | | | | | | | | 0,55 | 0,55 | |
| 12.37 | POSICIONADOR DE BOMBAS DOSADORAS | 24 | 16 | | | | | | | | | 0,55 | 0,55 | |
| 13.03 | ROSCA DE DOSAGEM DE PÓ | 2 | 1 | 0 | -0,1 | 0,60 | 0,00129 | 5.534,88 | 72,0% | 0,00 | 66,00% | 0,00 | 0,37 | |
| 14.01 | PONTE GRUA TOMADA D'ÁGUA DO MAR | 1 | 1 | | | | | | | | | 4,00 | 4 | |
| 14.02 | PONTE GRUA BOMBEAMENTO PRODUTO | 1 | 1 | | | | | | | | | 4,00 | 4 | |
| 14.03 | PONTE GRUA BOMBEAMENTO A.P. | 1 | 1 | | | | | | | | | 5,50 | 5,5 | |

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Cagece Companhia de Água e Esgoto do Ceará

ECOAGUA

## LISTA CONSUMIDORES

**SOLUÇÃO: Base** **FOLHA**

| Nº ITEM | DESCRIÇÃO | NÚMERO UNIDADE TOTAL | NÚMERO UNIDADE OPERAÇÃO | POTÊNCIA kW | TENSÃO V. | VELOCIDADE rpm. | PROTEC. | ISOLAMENTO | DADOS EM CONDIÇÕES NOMINAIS INTENSIDADE A. | FATOR % | RENDIMENTO % | TIPO ARRANQUE | TIPO MOTOR | NOTAS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.01 | BOMBA AGUA DO MAR NA CAPTAÇÃO | 5 | 4 | 710 | 6600 | 1000 | IP-55 | F | 72 | 89,00% | 97,00% | F.V. | | Marcha/Paro en local y seta emergencia |
| 1.03 | MOTO VALVULAS DE DESCARGA | 5 | 4 | 0,55 | 380 | | IP-55 | F | 1 | 79,00% | 71,00% | Inverter | | Marcha/Paro local |
| 3.01 | B. BOOSTER ALIMENTAÇÃO B.A.P. | 4 | 4 | 315 | 380 | 1500 | IP-55 | F | 565 | 88,00% | 96,30% | F.V. | | Marcha/Paro local |
| 3.02 | MOTO-VÁLVULA DE ASPIRAÇÃO E DESCARGA | 8 | 8 | 0,55 | 380 | | IP-55 | F | 1 | 79,00% | 71,00% | Inverter | | Marcha/Paro local |
| 4.01 | MOTOBOMBA DE ALTA PRESSÃO | 4 | 4 | 1800 | 6600 | 3000 | IP-55 | F | 181 | 89,50% | 97,50% | Soft Starter | | Marcha/Paro en local y seta emergencia |
| 4.02 | MOTO-VÁLVULA DE ASPIRAÇÃO E DESCARGA | 8 | 8 | 0,55 | 380 | | IP-55 | F | 1 | 79,00% | 71,00% | Inverter | | Marcha/Paro local |
| 4.03 | BOMBAS DE RECIRCULAÇÃO | 4 | 4 | 315 | 380 | 1500 | IP-55 | F | 565 | 88,00% | 96,30% | F.V. | | Marcha/Paro local |
| 4.04 | MOTO-VÁLVULA DE ASPIRAÇÃO E DESCARGA | 8 | 8 | 0,55 | 380 | | IP-55 | F | 1 | 79,00% | 71,00% | Inverter | | Marcha/Paro local |
| 7.01 | POTÊNCIA DE DESCARGA DO PRODUTO | 5 | 4 | 160 | 380 | 1500 | IP-55 | F | 292 | 87,00% | 95,80% | Soft Starter | | Marcha/Paro local |
| 8.01 | MOTOBOMBA DE LAVADO DE FILTROS | 3 | 2 | 200 | 380 | | IP-55 | F | 364 | 87,00% | 96,20% | Soft Starter | | Marcha/Paro local |
| 8.02 | SOPRADORES LAVAGEM DE FILTROS | 3 | 2 | 75 | 380 | | IP-55 | F | 140 | 86,00% | 94,70% | Soft Starter | | Marcha/Paro local |
| 9.01 | POTÊNCIA QUIMICA | 2 | 2 | 160 | 380 | 1500 | IP-55 | F | 292 | 87,00% | 95,80% | Soft Starter | | Marcha/Paro local |
| | | | | | | | | | | | | | | Marcha/Paro local |
| 9.03 | MOTOBOMBA DE DESLOCAMENTO | 1 | 1 | 160 | 380 | 1500 | IP-55 | F | 292 | 87,00% | 95,80% | Soft Starter | | Marcha/Paro local |
| 9.05 | RESISTÊNCIA DE AQUECIMENTO L.Q. | 1 | 1 | 208 | 380 | | IP-55 | F | 316 | 100,00% | 100,00% | Soft Starter | | Marcha/Paro local |
| 11.02 | HIDROCOMPRESSORES ÁGUA DE SEWRVIÇO | 2 | 1 | 4 | 380 | | IP-55 | F | 9 | 83,00% | 84,00% | Direct | | Marcha/Paro local |
| 11.03 | EXTRATOR SILENCIADOR SOPR. F.A. | 3 | 2 | 1,1 | 380 | | IP-55 | F | 3 | 81,00% | 74,00% | Direct | | |

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Cagece Companhia de Água e Esgoto do Ceará

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## LISTA CONSUMIDORES

**SOLUÇÃO: Base** **FOLHA**

| Nº ITEM | DESCRIÇÃO | NÚMERO UNIDADE | | POTÊNCIA | TENSÃO | VELOCIDADE | PROTEC. | ISOLAMENTO | DADOS EM CONDIÇÕES NOMINAIS | | | TIPO ARRANQUE | TIPO MOTOR | NOTAS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TOTAL | OPERAÇÃO | Kw | V. | rpm. | | | INTENSIDADE A | FATOR % | RENDIMENTO % | | | |
| 12.1 | BOMBA DE DOSIFICAÇÃO ACIDO SULFURICO | 3 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| 12.2 | BOMBA DE DOSIFICAÇÃO HIPOCLORITO SÓDICO | 3 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| 12.3 | BOMBA DE DOSIFICAÇÃO METABISULFITO SÓDICO | 3 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| 12.4 | BOMBA DE DOSIFICAÇÃO CLORETO FERRICO | 3 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| 12.5 | BOMBA DE DOSIFICAÇÃO DISPERSANTE | 3 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| 12.9 | BOMBA DE DOSIFICAÇÃO HIDROXIDO DE CALCIO | 3 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| 12.10 | BOMBA DE DOSIFICAÇÃO FLUORSILICATO DE SODI | 3 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| 12.11 | BOMBA DE DOSIFICAÇÃO HIPOCLORITO DE SODIO | 3 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| 12.22 | BOMBA TRANSFERÊNCIA DE ACIDO SULFURICO | 1 | 1 | 5,5 | 380 | | IP-55 | F | 12 | 81,00% | 86,00% | Soft Starter | | Marcha/Paro local |
| 12.23 | BOMBA TRANSFERÊNCIA DE HIPOCLORITO SÓDICO | 2 | 2 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | Marcha/Paro local |
| 12.24 | AGITADOR DE METABISULFITO SODICO | 1 | 1 | 1,5 | 380 | | IP-55 | F | 4 | 81,00% | 74,00% | Direct | | Marcha/Paro local |
| 12.25 | BOMBA TRANSFERÊNCIA DE CLORETO FÉRRICO | 1 | 1 | 5,5 | 380 | | IP-55 | F | 12 | 81,00% | 86,00% | Soft Starter | | Marcha/Paro local |
| 12.26 | AGITADOR DE DISPERSANTE | 2 | 2 | 0,55 | 380 | | IP-55 | F | 1 | 79,00% | 71,00% | Direct | | Marcha/Paro local |
| 12.27 | EVAPORADOR DE ANHIDRIDO CARBONICO | 1 | 1 | 15 | 380 | | IP-55 | F | 30 | 84,00% | 90,00% | Soft Starter | | |
| 12.28 | SISTEMA DE LLENADO DE LOS SILOS HIDROXIDO CA | 1 | 1 | 1,5 | 380 | | IP-55 | F | 4 | 81,00% | 74,00% | Direct | | Marcha/Paro local |
| 12.29 | AGITADOR DE FLUOR | 1 | 1 | 0,55 | 380 | | IP-55 | F | 1 | 79,00% | 71,00% | Direct | | Marcha/Paro local |
| 12.37 | POSICIONADOR DE BOMBAS DOSADORAS | 24 | 16 | 0,55 | 250 | | IP-55 | F | 2 | 79,00% | 71,00% | Direct | | |
| 13.03 | ROSCA DE DOSAGEM DE PÓ | 2 | 1 | 0,37 | 380 | | IP-55 | F | 1 | 77,00% | 66,00% | Direct | | |
| | | | | | | | | | | | | | | Marcha/Paro local |
| 14.01 | PONTE GRUA TOMADA D'ÁGUA DO MAR | 1 | 1 | 4 | 380 | | IP-55 | F | 9 | 83,00% | 84,00% | Direct | | Marcha/Paro local |
| 14.02 | PONTE GRUA BOMBEAMENTO PRODUTO | 1 | 1 | 4 | 380 | | IP-55 | F | 9 | 83,00% | 84,00% | Direct | | |
| 14.03 | PONTE GRUA BOMBEAMENTO A.P. | 1 | 1 | 5,5 | 380 | | IP-55 | F | 12 | 81,00% | 86,00% | Soft Starter | | Marcha/Paro local |

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| | | |
|---|---|---|
| PLANTA.............................. | **Fortaleza** | DATA 02-Mar-18 |
| CLIENTE.............................. | CAGECE | |
| SOLUÇÃO.............................. | Base () | |

## CONSUMO DE ENERGIA

| Nº ITEM | DESCRIÇÃO | NÚMERO UNIDADE | | POTÊNCIA UNITÁRIA (KW) | | HORAS ANUAIS | ENERGIA ANUAL KWH/ANO |
|---|---|---|---|---|---|---|---|
| | | TOTAL | OPERAÇÃO | INSTALADA | CONSUMIDA | | |
| 1.01 | BOMBA AGUA DO MAR NA CAPTAÇÃO | 5 | 4 | 710,00 | 560,45 | 8.400 | 18.831.128,67 |
| 3.01 | B. BOOSTER ALIMENTAÇÃO B.A.P. | 4 | 4 | 315,00 | 276,82 | 8.400 | 9.301.124,89 |
| 4.01 | MOTOBOMBA DE ALTA PRESSÃO | 4 | 4 | 1.800,00 | 1.674,62 | 8.400 | 56.267.079,35 |
| 4.03 | BOMBAS DE RECIRCULAÇÃO | 4 | 4 | 315,00 | 274,29 | 8.400 | 9.216.099,71 |
| 7.01 | POTÊNCIA DE DESCARGA DO PRODUTO | 5 | 4 | 160,00 | 134,67 | 8.400 | 4.524.936,37 |
| 8.01 | MOTOBOMBA DE LAVADO DE FILTROS | 3 | 2 | 200,00 | 153,61 | 5.863 | 1.801.185,69 |
| 8.02 | SOPRADORES LAVAGEM DE FILTROS | 3 | 2 | 75,00 | 48,36 | 2.199 | 212.631,37 |
| 9.01 | POTÊNCIA QUIMICA | 2 | 2 | 160,00 | 132,13 | 664 | 175.550,68 |
| 9.03 | MOTOBOMBA DE DESLOCAMENTO | 1 | 1 | 160,00 | 132,13 | 3 | 420,55 |
| 11.02 | HIDROCOMPRESSORES ÁGUA DE SEWRVIÇO | 2 | 1 | 4,00 | 2,66 | 2.100 | 5.580,70 |
| 12.01 | BOMBAS DOSADORAS PRÉ TRATAMENTO | 15 | 10 | 0,37 | 0,37 | 8.400 | 31.080,00 |
| 12.10 | BOMBAS DOSADORAS PÓS TRATAMENTO | 9 | 6 | 0,37 | 0,37 | 8.400 | 18.648,00 |
| 12.37 | POSICIONADOR DE BOMBAS DOSADORAS | 24 | 16 | 0,55 | 0,55 | 2.772 | 24.393,60 |
| 13.03 | ROSCA DE DOSAGEM DE PÓ | 2 | 1 | 0,37 | 0,00 | 233 | 0,00 |
| 14.00 | AGITADORES E B TRANSFERÊNCIA | 1 | 1 | 31,39 | 28,33 | 1.400 | 39.666,09 |
| 9.05 | RESISTÊNCIA DE AQUECIMENTO L.Q. | 1 | 1 | 207,85 | 207,85 | 664 | 138.076,77 |
| 14.01 | PORTICOS | 1 | 1 | 13,50 | 13,50 | 120 | 1.620,00 |
| 15.01 | VÁLVULAS MOTORIZADAS | 29 | 28 | 15,95 | 15,95 | 1.440 | 22.968,00 |
| 11.03 | VENTILADORES DOS SOPRADORES | 3 | 2 | 1,10 | 1,10 | 2.199 | 4.836,78 |
| 19.00 | PAINEL DE CONTROLE E ELETRO VÁLVULAS | 1 | 1 | 45,00 | 45,00 | 8.400 | 378.000,00 |
| 20.00 | ILUMINAÇÃO | 1 | 1 | 30,00 | 30,00 | 4.380 | 131.400,00 |
| 21.00 | AIR ACONDICIONADO | 1 | 1 | 70,00 | 70,00 | 4.380 | 306.600,00 |
| 24.00 | PERDA NA TRANSFORMAÇÃO, DISTRIBUÇÃO E Y FATOR DE SEGURANÇA | | | | | | 3.137.103,93 |

| | |
|---|---|
| **CONSUMO TOTAL DE ENERGÍA (KWH)** | **104.570.131,16** |
| **PRODUÇÃO GARANTIDA (M³/D)** | **86.400,00** |
| **PRODUÇÃO TOTAL ANUAL (M³)** | **30.240.000,00** |
| **CONSUMO ESPECIFICO ENERGIA (KWH/M³)** | **3,46** |

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Source: GS Inima



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## 14.5. Equipment Technical Specifications - Hydromechanical

### 14.5.1. Electromechanical Devices

#### 14.5.1.1. Seawater Intake Pumps

**GENERAL INFORMATION**

| | | | |
|---|---|---|---|
| ✓ | Service: | Pumping intake | |
| ✓ | Type of drive | Electric motor with inverter | |
| ✓ | Number of equal pumps in operation | 4 | |
| ✓ | Number of equal pumps in reserve | 1 | |

**DESIGN CHARACTERISTICS**

| | | | |
|---|---|---|---|
| ✓ | Flow at predetermined site | m3/h | 2,293 |
| ✓ | Projected TDH | m.c.l. | 82.53 |
| ✓ | Suction pressure at predetermined site | barg | 0.48 |
| ✓ | Room temperature | ºC | 40-20 |
| ✓ | Maximum seawater temperature | ºC | 30 |
| ✓ | Minimum seawater temperature | ºC | 22 |
| ✓ | Construction model | | Horizontal, between bearings |
| ✓ | Number of stages | | 1 |
| ✓ | Type of impeller | | Simple suction |
| ✓ | Impeller design | | Closed |
| ✓ | Type of body | | Surface |
| ✓ | Body division | | Radial |
| ✓ | Body assembly | | Central line |
| ✓ | Rotation direction (viewed from the motor) | | Clockwise |
| ✓ | Bearing model lifespan | h. | 60,000 |
| ✓ | RTD/Pt-100 Nº by bearing | | 1 |
| ✓ | Type of motor coupling | Flexible | |

**OPERATION CHARACTERISTICS**

| | | | |
|---|---|---|---|
| ✓ | Normal work flow | m3/h | 2,293 |
| ✓ | Maximum expected work flow | m3/h | 2,522 |
| ✓ | Minimum expected work flow | m3/h | 2,064 |
| ✓ | TDH at normal flow | m.c.l. | 82.53 |
| ✓ | Minimum TDH at minimum flow | m.c.l. | 40 |
| ✓ | Suction pressure | bar | 0.48 |
| ✓ | Pump performance with regular flow | % | 83.8 |
| ✓ | Power demanded by pump | kW | 552 |
| ✓ | Noise level during normal operation (incl. Motor) | dB | 85 |

**PUMP MATERIAL**

| | | |
|---|---|---|
| ✓ | Body | Superduplex PREN >40 |
| ✓ | Impeller | Superduplex PREN >40 |
| ✓ | Axis | Superduplex PREN >40 |
| ✓ | Axis housing | Superduplex PREN >40 |

### 14.5.2. Closed Filters

First Stage of Filtration

**GENERAL INFORMATION**:

| | | | |
|---|---|---|---|
| ✓ | Service: | First stage filters | |
| ✓ | Number of filters: | | 14 |

**WEATHER**:

| | | | |
|---|---|---|---|
| ✓ | Maximum temperature: | ° C | 40 |
| ✓ | Minimum temperature: | ° C | 20 |
| ✓ | Relative humidity: | % | 75 |
| ✓ | Annual rainfall: | mm | 133 |

**FLUID CHARACTERISTICS**:

| | | | |
|---|---|---|---|
| ✓ | Type of fluid: | Seawater/brine backwashing | |
| ✓ | Conductivity (25° C): | µS/cm | 58,847 |
| ✓ | Density: | kg/L | 1.025 |
| ✓ | Viscosity: | cps | 0.96 |
| ✓ | Maximum temperature: | ° C | 30 |

**DESIGN CONDITIONS**:

| | | | |
|---|---|---|---|
| ✓ | Project code: | ASME Section VIII Division 1 or similar | |
| ✓ | Installation: | Extreme weather | |
| ✓ | Design temperature: | ° C | 40 |
| ✓ | Project pressure: | barg | 4.5 |
| ✓ | Pressure proof: | barg | 6.75 |
| ✓ | Work flow: | m3/h | 8,024 |
| ✓ | Maximum differential pressure of support plate: | barg | 1.5 |
| ✓ | Useful filtration surface by filter: | m2 | 88.43 |



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- ✓ Speed of filtration: m/h 6.5
- ✓ Speed of filtration during backwash: m/h 7
- ✓ Number of filtering beds: 3
- ✓ Height and type of first filtering bed (starting from upper surface): 700 mm, anthracite effective size 1.90 mm and uniformity coefficient 1.4
- ✓ Height and type of second filtering bed: 400 mm, silica sand with 0.6 mm effective size and uniformity coefficient 1.45
- ✓ Height and third filter bed type: 200 mm, silica sand with effective size 2 mm; uniformity coefficient 1,7
- ✓ Ferrule thickness: mm Calculated according to model code
- ✓ Bottom thickness: mm Calculated according to model code
- ✓ Support plate thickness: mm Calculated according to model code

**FILTER AND SUPPORT PLATE CHARACTERISTICS**:

- ✓ Type: Horizontal pressure filters
- ✓ Design and construction for a useful life of: 25 years
- ✓ Design and construction for a continuous operation of: h/year 8600
- ✓ Head: Korbbogen

**ACCESSORIES**:

- ✓ Lifting Eye Bolts (yes/no): Yes
- ✓ Identification plate Yes

**CONNECTIONS (Type, DN and PN/Schedule):**

- ✓ Water inlet: 2 unit Flanges DIN DN500 PN10
- ✓ Water outlet: 2 units Flanges DIN DN500 PN10
- ✓ Drainage: 1 unit Flanges DIN DN350 PN10
- ✓ Safety valve/disc rupture: 1 unit Flanges DIN DN250 PN16
- ✓ Ventilation: 1 unit Flanges DIN DN500 PN10
- ✓ Manway access covers: 3 units Flanges DIN DN500 PN10, one at the top of the ferrule, a second at the inferior portion and a third at one of the bottom areas.

**MATERIALS**:

- ✓ Ferrule and bottom: S 275 JR
- ✓ Support plate: S 275 JR
- ✓ Flanges RSt 37.2
- ✓ Interior lining: surface cleaning with SA 2 ½ sandblasting, application of glue, rubber sheet with glue, dielectric inspection, interior autoclave vulcanization and post-vulcanization inspection or similar procedures.
- ✓ Exterior painting: sandblasting at SA-2 ½, application of a 100-micron epoxy primer coat, application of an intermediate 50-micron paint coat.
- ✓ Exterior protection: UVA radiation protection
- ✓ Joints: Neoprene
- ✓ Screws: Stainless steel

**NOZZLES:**

- ✓ Number of nozzles per filter: Units 700
- ✓ Fixation type: Threaded
- ✓ Nozzle material Polypropylene
- ✓ Nozzle clamp material: Polypropylene
- ✓ Washer material: EPDM
- ✓ DIMENSIONS:

Interior filter diameter m 4

Filter cylindrical length (neck included) m 22

- ✓ <u>Second filtration stage</u>
- ✓ GENERAL INFORMATION:

Service: Second stage filters

Number of filters: 8

**WEATHER**:

- ✓ Maximum temperature: ° C 40
- ✓ Minimum temperature: ° C 20
- ✓ Relative humidity: % 75
- ✓ Annual rainfall: mm 133

**FLUID CHARACTERISTICS**:

- ✓ Type of fluid: Seawater/brine backwashing
- ✓ Conductivity (25° C): µS/cm 58,847
- ✓ Density: kg/L 1.025
- ✓ Viscosity: cps 0.96
- ✓ Maximum temperature: ° C 30

**DESIGN CONDITIONS**:

- ✓ Design code: ASME Section VIII Division 1 or similar
- ✓ Installation: According to the weather
- ✓ Design temperature: ° C 40
- ✓ Project pressure barg 4.5



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- ✓ Pressure proof barg 6.75
- ✓ Work flow: m3/h 8,024
- ✓ Maximum support plate differential pressure: barg 1.5
- ✓ Useful filtration surface by filter: m2 92.51
- ✓ Speed of filtration: m/h 10.8
- ✓ Speed of filtration during backwash: m/h 12.4
- ✓ Number of filtering beds: 2
- ✓ Height and type of first filtering bed (starting from upper surface): 500 mm, anthracite with effective size 0.3 mm and uniformity coefficient 1.4
- ✓ Height and type of second filtering bed: 200 mm, silica sand with effective size 2 mm e Uniformity coefficient 1.7
- ✓ Ferrule thickness: mm Calculated according to model code
- ✓ Bottom thickness: mm Calculated according to model code
- ✓ Support plate thickness: mm Calculated according to model code

**FILTER AND SUPPORT PLATE CHARACTERISTICS**:

- ✓ Type: Horizontal pressure filters
- ✓ Design and construction for a useful life of: 25 years
- ✓ Design and construction for a continuous operation of: 8600 h/year
- ✓ Heads: Korbbogen

**ACCESSORIES**:

- ✓ Lifting eye bolts (yes/no): Yes
- ✓ Identification plate: Yes

**CONNECTIONS (Type, DN and PN/Schedule):**

- ✓ Water inlet: 2 units Flanges DIN DN500 PN10
- ✓ Water outlet: 2 unit Flanges DIN DN500 PN10
- ✓ Drainage: 1 unit Flanges DIN DN350 PN10
- ✓ Safety valve/disc rupture: 1 unit Flanges DIN DN250 PN16
- ✓ Ventilation: 1 unit Flanges DIN DN500 PN10
- ✓ Manway access covers: 3 units Flanges DIN DN500 PN10, one at the top of the ferrule, a second at the inferior portion and a third at one of the bottom areas.

**MATERIAL**:

- ✓ Ferrule and heads: S 275 JR
- ✓ Support plate: S 275 JR
- ✓ Flanges RSt 37.2
- ✓ Interior lining: surface cleaning with SA 2 ½ sandblasting, application of glue, rubber sheet with glue, dielectric inspection, interior autoclave vulcanization and post-vulcanization inspection or similar procedures.
- ✓ Exterior painting: sandblasting at SA-2 ½, application of a 100-micron epoxy primer coat, application of an intermediate 50-micron paint coat.
- ✓ Exterior protection UVA radiation protection
- ✓ Joints: Neoprene
- ✓ Screws: Stainless steel

**NOZZLES**:

- ✓ Number of nozzles per filter: Units 416
- ✓ Diameter of pores in the support plate: mm
- ✓ Fixation type: Threaded
- ✓ Nozzle material Polypropylene
- ✓ Nozzle clamp material: Polypropylene
- ✓ Washer material: EPDM

**DIMENSIONS**:

- ✓ Interior filter diameter m 4
- ✓ Filter cylindrical length (neck included) m 22

### 14.5.3. Closed Filter Backwashing - Centrifugal Pumps

**GENERAL INFORMATION**

- ✓ Service: Filter backwashing
- ✓ Type of drive Soft starter
- ✓ Number of equal pumps in operation 2
- ✓ Number of equal pumps in reserve 1

**DESIGN CHARACTERISTICS**

- ✓ Flow at predetermined site m3/h 1,914
- ✓ Projected TDH m.c.l. 21.60
- ✓ Suction pressure at predetermined site barg 0.05
- ✓ Room temperature ºC 40-20
- ✓ Seawater maximum temperature ºC 30
- ✓ Seawater minimum temperature ºC 22
- ✓ Construction model Horizontal, between bearings
- ✓ Number of stages 1


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- ✓ Type of impeller Simple suction
- ✓ Impeller design Closed
- ✓ Type of body Surface
- ✓ Body division Radial
- ✓ Body assembly Center line
- ✓ Rotation direction (with view from motor) Clockwise
- ✓ Bearing model lifespan h. 60,000
- ✓ Nº de RTD/Pt-100 by bearing 1
- ✓ Type of motor coupling Flexible

**OPERATION CHARACTERISTICS**

- ✓ Normal work flow m3/h 1,914
- ✓ Maximum expected work flow m3/h 2,105
- ✓ Minimum expected work flow m3/h 1,723
- ✓ TDH at normal flow m.c.l. 21.6
- ✓ Minimum TDH at minimum flow m.c.l. 12
- ✓ Suction pressure bar 0.05
- ✓ Pump performance with regular flow % 80
- ✓ Power demanded by pump kW 148
- ✓ Noise level in normal operation (incl. Motor) dB 85

**PUMP MATERIAL**

- ✓ Body Superduplex PREN >40
- ✓ Impeller Superduplex PREN >40
- ✓ Axis Superduplex PREN >40
- ✓ Axis housing Superduplex PREN >40

### 14.5.4. Closed Filter Backwash Blowers

**GENERAL INFORMATION:**

- ✓ Service: Sand and anthracite filter washing
- ✓ Number of blowers: Unit 3 (2+1)

**WEATHER:**

- ✓ Maximum temperature: ° C 40
- ✓ Minimum temperature: ° C 20

**FLUID CHARACTERISTICS**:

- ✓ Type of fluid: Air
- ✓ Specific weight Kg/m3 1,2
- ✓ Maximum temperature: ° C 50

**DESIGN CONDITIONS**:

- ✓ Suction temperature: ° C 20-40
- ✓ Suctioned flow: Nm3/h 2.211
- ✓ Suction pressure: barg atmospheric
- ✓ Differential pressure: barg 0.6

**BLOWERS CHARACTERISTICS**:

- ✓ Type: 3-lobe rotating plungers
- ✓ Design and construction for a useful life of: 25 years
- ✓ Design and construction for a continuous operation of: h/year 8,600
- ✓ Lubrification: Oil
- ✓ Coupling: Flexible
- ✓ Suction flow tolerance (s/DIN): % ± 5
- ✓ Suction flow tolerance (s/DIN): % ± 5
- ✓ Noise level tolerance (s/DIN): dB(A) ± 2
- ✓ Maximum sound level at 1 m with sound proof cabin: dB(A) <85

**ACCESSORIES**:

- ✓ Pulley set (yes/no): yes
- ✓ Set of straps (yes/no): yes (automatic extension)
- ✓ Transmission protection (yes/no): yes
- ✓ Suction air filter (yes/no): yes
- ✓ Silent suction (yes/no): yes
- ✓ Silent drive (yes/no): yes
- ✓ Safety valve (yes/no): yes
- ✓ Check valve (yes/no): yes
- ✓ Vacuum valve: yes
- ✓ Clogging detector (yes/no): yes
- ✓ Flexible cuff: yes
- ✓ Elastic supporters: yes
- ✓ Oil level indicator: yes
- ✓ Differential pressure manometer(yes/no): yes



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- ✓ Pressure limiting pressostat: yes
- ✓ Temperature limiting thermostat: yes
- ✓ Sound proof cabin (yes/no): yes
- ✓ Forced air-conditioning unit (yes/no): yes
- ✓ Cable entries: yes
- ✓ Bench (yes/no): no

**CONNECTIONS (Type, DN and PN/Schedule):**

- ✓ Drive: Flanges DIN (GRP DN-400 booster pipelines)

**MATERIALS**:

- ✓ Stator rotor: GG-20
- ✓ Heads: GG-25
- ✓ Lids: GG-25
- ✓ Plungers: GG-20

**MOTOR**:

- ✓ Nominal voltage: kW 45.4
- ✓ Voltage/phases/frequency: V/ /Hz 400/3/50
- ✓ Protection level: IP55
- ✓ Isolation: F

## 14.5.5. Cartridge filters

### 14.5.5.1. Process

**GENERAL INFORMATION:**

- ✓ Service: Safety filters before Reverse Osmosis
- ✓ Number of filters: 8

**WEATHER**:

- ✓ Maximum temperature: ° C 40
- ✓ Minimum temperature: ° C 20

**FLUID CHARACTERISTICS**:

- ✓ Type of fluid: Seawater TDS =40,150 mg/L/cleaning solution pH 2-11
- ✓ Maximum temperature: ° C 30

**DESIGN CONDITIONS**:

- ✓ Design code: ASME Section VIII. Div. 1or similar
- ✓ Installation: According to the weather
- ✓ Design temperature: ° C 40
- ✓ Project pressure barg 4.5
- ✓ Pressure proof barg According to design code
- ✓ Work pressure: barg 4
- ✓ Work flow by filter: m3/h 1003
- ✓ Maximum differential pressure of support plate: barg 2
- ✓ Maximum velocity in connections: m/sec Recommended by manufacturer
- ✓ Ferrule thickness: mm Calculated according to model code
- ✓ Bottom thickness: mm Calculated according to model code
- ✓ Support plate thickness: mm Calculated according to model code

**FILTER CHARACTERISTICS:**

- ✓ Type: Recommended by manufacturer
- ✓ Filter interior diameter: mm Recommended by manufacturer
- ✓ Filter body height or length: mm Recommended by manufacturer
- ✓ Design and construction for a useful life of: 25 years
- ✓ Design and construction for a continuous operation of: h/year 8600
- ✓ Head: Korbbogen or similar

**ACCESSORIES:**

- ✓ Lifting Eye Bolts (yes/no): Yes
- ✓ Identification plate Yes

**CONNECTIONS (Type, DN and PN/Schedule):**

- Water inlet: 1 unit Flanges DIN DN-450, PN-6
- Water outlet: 1 unit Flanges DIN DN-450, PN-6
- Drainage: 1 unit Recommended by manufacturer
- Ventilation: 1 unit Recommended by manufacturer
- Safety valve/disc rupture: 1 unit Recommended by manufacturer

**MATERIALS:**

- ✓ Ferrule and heads: GRP
- ✓ Support plate: Polypropylene
- ✓ Interior lining: Recommended by manufacturer
- ✓ Exterior protection UVA radiation protection
- ✓ Joints: Nitrile
- ✓ Screws: Steelinox
- ✓ Number of cartridges by filter Unit Recommended by manufacturer


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- Length: mm 1270
- Diameters: mm 61
- Absolute pore size: micras 10
- Nominal pore size: micras
- Beta ratio: 5,000
- Filtering surface per cartridge: m2 0.24
- Material: Polypropylene

### 14.5.5.2. Chemical Cleaning

**GENERAL INFORMATION:**

- Service: Safety filters before chemical cleaning
- Number of filters: 1
- Equipment tag:

**WEATHER**:

- Maximum temperature: ° C 40
- Minimum temperature: ° C 20

**FLUID CHARACTERISTICS**:

- Type of fluid: Cleaning solution pH 2-11
- Maximum temperature: ° C 45

**DESIGN CONDITIONS**:

- Design code: ASME Section VIII. Div. 1 or similar
- Installation: According to the weather
- Design temperature: ° C 40
- Project pressure barg 4.5
- Pressure proof According to design code
- Work pressure: barg 4
- Work flow by filter: m3/h 1,130
- Maximum differential pressure of support plate: barg 2
- Maximum velocity in connections: m/sec Recommended by manufacturer
- Ferrule thickness: mm Calculated according to model code
- Bottom thickness: mm Calculated according to model code
- Support plate thickness: mm Calculated according to model code

**FILTER CHARACTERISTICS**:

- Type: Recommended by manufacturer
- Filter interior diameter: mm Recommended by manufacturer
- Filter body height or length: mm Recommended by manufacturer
- Design and construction for a useful life of: 25 years
- Design and construction for a continuous operation of: h/year 8600
- Heads: Korbbogen or similar

**ACCESSORIES**:

- Lifting Eye Bolts (yes/no): Yes
- Identification plate Yes
- CONNECTIONS (Type, DN and PN/Schedule):
  - Water inlet: 1 unit Flanges DIN DN-450, PN-6
  - Water outlet: 1 unit Flanges DIN DN-450, PN-6
  - Drainage: 1 unit Recommended by manufacturer
  - Ventilation: 1 unit Recommended by manufacturer
  - Safety valve/disc rupture:1 unit Recommended by manufacturer

**MATERIALS**:

- Ferrule and heads: GRP
- Support plate: Polypropylene
- Interior lining: Recommended by manufacturer
- Exterior protection UVA radiation protection
- Joints: Nitrile
- Screws: Stainless steel

**CARTRIDGES**:

- Number of cartridges by filter: Unit Manufacturer recommendation
- Length: mm 1270
- Diameters: mm 61
- Absolute pore size: micras 10
- Filtering surface per cartridge: $m^2$ 0.24
- Material: Polypropylene

### 14.5.6. High-pressure pumps

**GENERAL INFORMATION**

- Service: High-pressure pumping
- Type of drive Soft starter



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- ✓ Number of equal pumps in operation 4
- ✓ Number of equal pumps in reserve 0

**DESIGN CHARACTERISTICS**

- ✓ Flow at predetermined site m3/h 915
- ✓ Projected TDH m.c.l. 543
- ✓ Suction pressure at predetermined site barg 10
- ✓ Room temperature ºC 40-20
- ✓ Seawater maximum temperature ºC 30
- ✓ Seawater minimum temperature ºC 22
- ✓ Construction model Horizontal, between bearings
- ✓ Number of stages 1
- ✓ Type of impeller Simple suction
- ✓ Impeller design Closed
- ✓ Type of body Surface
- ✓ Body division Radial
- ✓ Body assembly Center line
- ✓ Rotation direction (view from motor) Clockwise
- ✓ Bearing model lifespan h. 60,000
- ✓ Nº de RTD/Pt-100 by bearing 1
- ✓ Type of motor coupling Flexible

**OPERATION CHARACTERISTICS**

- ✓ Normal work flow m3/h 915
- ✓ Maximum expected work flow m3/h 1,006
- ✓ Minimum expected work flow m3/h 819
- ✓ TDH at normal flow m.c.l. 543
- ✓ Suction pressure bar 10
- ✓ Pump performance with regular flow % 85
- ✓ Power demanded by pump kW 1,633
- ✓ Noise level in normal operation (incl. Motor) dB 85

**PUMP MATERIAL**

- ✓ Body Superduplex PREN >40
- ✓ Impeller Superduplex PREN >40
- ✓ Axis Superduplex PREN >40
- ✓ Axis housing Superduplex PREN >40

### 14.5.7. BAP Feed Booster Pump

**GENERAL INFORMATION**

- ✓ Service: BAP Feed Booster Pump
- ✓ Type of drive Electric motor with VFD
- ✓ Number of equal pumps in operation 4
- ✓ Number of equal pumps in reserve 0

**DESIGN CHARACTERISTICS**

- ✓ Flow at predetermined site m3/h 915
- ✓ Projected TDH m.c.l. 83
- ✓ Suction pressure at predetermined site barg 2,5
- ✓ Room temperature ºC 40-20
- ✓ Seawater maximum temperature ºC 30
- ✓ Seawater minimum temperature ºC 22
- ✓ Construction model Horizontal, between bearings
- ✓ Number of stages 1
- ✓ Type of impeller Simple suction
- ✓ Impeller design Closed
- ✓ Type of body Surface
- ✓ Body division Radial
- ✓ Body assembly Center line
- ✓ Rotation direction (view from motor) Clockwise
- ✓ Bearing model lifespan h. 60,000
- ✓ Nº de RTD/Pt-100 by bearing 1
- ✓ Type of motor coupling Flexible

**OPERATION CHARACTERISTICS**

- ✓ Normal work flow m3/h 915
- ✓ Maximum expected work flow m3/h 1,006
- ✓ Minimum expected work flow m3/h 819
- ✓ TDH at normal flow m.c.l. 83
- ✓ Minimum TDH at minimum flow m.c.l. 40
- ✓ Suction pressure bar 2.5
- ✓ Pump performance with regular flow % 84



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- ✓ Power demanded by pump kW 254
- ✓ Noise level in normal operation (incl. Motor) dB 85

**PUMP MATERIAL**

- ✓ Body Superduplex PREN >40
- ✓ Impeller Superduplex PREN >40
- ✓ Axis Superduplex PREN >40
- ✓ Axis housing Superduplex PREN >40

### 14.5.8. Pressure Boxes

**GENERAL INFORMATION:**

- ✓ Service: Reverse Osmosis and seawater membrane containers
- ✓ Number of boxes/line: 226
- ✓ Number of lines: 4
- ✓ Total number of boxes: 904

**WEATHER:**

- ✓ Maximum temperature: ° C 40
- ✓ Minimum temperature: ° C 20
- ✓ Relative humidity: % 75
- ✓ Annual rainfall: mm 133

**FLUID CHARACTERISTICS:**

- ✓ Type of fluid: seawater/brine/cleaning solution pH 2-12
- ✓ Conductivity at 20°C: μS/cm 58,847
- ✓ Density: kg/L 1.025
- ✓ Viscosity: cps 0.96
- ✓ Maximum temperature: ° C 30

**DESIGN CONDITIONS**:

- ✓ Design code: ASME Section X
- ✓ Installation: Indoors
- ✓ Design temperature: ° C 40
- ✓ Operation pressure: barg 63

**TUBE CHARACTERISTICS**:

- ✓ Design and construction for a useful life of: years 25
- ✓ Design and construction for a continuous operation of: h/year 8600
- ✓ Tube thickness: According to design code
- ✓ Membrane diameter: in 8
- ✓ Membrane length: in 40
- ✓ Membrane capacity per tube: 7
- ✓ Raw water inlet/brine outlet ports: Multiport
- ✓ For each rack with 130 boxes:
- ✓ Number of raw water inlet/brine outlet ports: 44 boxes with 1 water inlet port and 1 brine outlet port.
- ✓ 86 with 2 water inlet ports and 2 brine outlet ports

**ACCESSORIES**:

- ✓ Membranes adapters: yes
- ✓ Closing, opening, retention and support devices (yes/no): yes
- ✓ Tube support (yes/no): yes (3 per tube)
- ✓ Clamps: yes (3 per tube)
- ✓ Special tools for tube assembly: Yes (if applicable)

**CONNECTIONS (Type, DN and PN/Schedule):**

- ✓ Raw water inlet: 2 ½ ”
- ✓ Brine outlet: 2 ½ ”
- ✓ Product water outlet: 1” PN-10 (minimum)

**MATERIALS:**

- ✓ Tube body: Epoxy resin and fiberglass reinforcement
- ✓ Seawater inlets and brine outlets Superduplex PREN>40
- ✓ Permeate outlet: Polypropylene
- ✓ Membrane adapters: Thermoplastic
- ✓ Locking elements: EPDM
- ✓ Retention and support elements: Steelinox 316L or similar
- ✓ Tube support: Polyurethane or similar
- ✓ Clamp: Steelinox 316L or similar
- ✓ Finish: Polyurethane or similar

### 14.5.9. Electrical equipment

#### 14.5.9.1. Medium voltage cells

**GENERAL INFORMATION**

- ✓ Service: Medium voltage 6.6kV distribution cells
- ✓ Function / Number of cells: - 2 inlet pipes with bar measurement



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- 4 motor protections
- 4 transformer protections of 6.6 / 0.4 kV
- 4 VDF seawater pump motor protection
- 1 Coupling

**DESIGN RESOURCES**

| | |
|---|---|
| ✓ Altitude: | <1000 m.s.n.m. |
| ✓ Max. Room temperature / outside minimum: | 30/0 ºC |
| ✓ Project temperature for all equipment: | 40 ºC |
| ✓ Relative humidity: | 75% |
| ✓ Facility conditions: | Indoor electrical room heating |
| ✓ Environmental classification: | Saline solution |
| ✓ Environmental contamination level: | Very high (IV) (IEC 60815) |
| ✓ Environmental corrosivity rating: | C3 (ISO 9223) |
| ✓ Construction Standard: | IEC 62271-200 |
| ✓ Type of service: | Heavy continuous |
| ✓ Nominal frequency: | 60 Hz |
| ✓ Nominal voltage: | 12 kV |
| ✓ Work voltage: | 6.6 kV |
| ✓ Insulation level at industrial frequency: | 28 kV / min. |
| ✓ Electrical discharge impulse insulation level: | 75 kVef / s |
| ✓ Nominal current at the main bars: | 2500A |
| ✓ Branching bar nominal current: | 630A |
| ✓ Maximum heat level allowed: | IEC 60694. Fit 4.4.2 |
| ✓ Short-term nominal current in main bars: | 25 kAeff / s |
| ✓ Maximum allowable nominal current value: | 80 kAcr |
| ✓ Grounding system: | Earthing |
| ✓ Auxiliary voltage and maneuver command: | 127 Vcc |
| ✓ Lighting auxiliary voltage and heating resistance: | 220 Vac |
| ✓ Type of cabinet e construction: | Metal clad |
| ✓ Class/ cutoff material: | PM / metal panels |
| ✓ Insulation means: | air |
| ✓ Service continuity class: | LSC-2B |
| ✓ Internal arc classification: | AFLR 40 kA / 1s |
| ✓ Protection level: | IP42 |
| ✓ Internal protection level: | IP 2X |
| ✓ Accessibility: | Frontal type A, authorized personnel |
| ✓ Cable inlet: | Inferior |
| ✓ Cable outlet: | Inferior |
| ✓ Type of feed cable: | 6/10 kV Cu (XLPE / PVC / H16 / PVC) IEC 60502-2 |
| ✓ Cable terminals: | Reinforced plugs (screwed) |

✓ Accessories: Heating resistance by cabinet, thermostat, mechanical and/or electrical interlocks, inspection windows, cabinet front nameplate and mimic buses.

**EQUIPMENT**

✓ Bars: Cu with PVC sleeve and silver joints. A grounding bar will be included.

✓ Switch: Three-phase, vacuum cut, removable in the car, manual and electrical operation, spring loading by accumulated energy, with closing coils and contacts for status signaling. Resistance class E2 / 10,000 M2.

✓ Grounding disconnector: Endurance E2 / 1000-M0

✓ Load disconnector: Endurance E2 / 1000-M0

✓ Current transformers: dry type, transformer ratio 2500/1 and 630/5/5 A, minimum precision power 15 VA, accuracy class 0.5s/5P10, thermal rating factor 200, permissible overcurrent Fs <= 5, short-circuit thermal current 5 kA

✓ Voltage transformers: dry type, withdrawable, transformer ratio 6.600 V/120√3, V-120/√3 V, minimum accuracy power 30 VA, Minimum accuracy class: 0.5 protection relays, 0.2 network analyzer, 3P ferroresonance.

✓ Protections, signage and communication:
- LED voltage pressure sensors
- Position and status indicator
- Phase correspondence verifier
- Local / remote control switch
- Manual reset lock-out relay
- Combined surge arrester Type 1 and 2, 100kA
- Multifunctional electronic relay (according to the single-line diagram)
- Modbus communication protocol
- Communication port RS232



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- Communication port RS485

### 14.5.9.2. 69 / 6.6kV Transformer

**GENERAL INFORMATION**

- ✓ Service: 69 / 6.6 KV transformation
- ✓ Number of equal transformers: 2 (1 + 1)

**DESIGN RESOURCES**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Outdoor maximum / minimum temperature: 30/0 ºC
- ✓ Project temperature: 40 ºC
- ✓ Relative humidity: 75%
- ✓ Type of installation: Outdoors
- ✓ Environmental classification: High degree of marine pollution (IV) (IEC 60815), environmental corrosivity classification C3 (ISO 9223).
- ✓ Type of construction: Oil, IEC60076
- ✓ Refrigeration: ONAF
- ✓ Connection group: YNyn0
- ✓ Neutral grounding method: Low resistance
- ✓ Climatic class: C1
- ✓ Environmental class: E2
- ✓ Fire behavior class: F1
- ✓ Nominal frequency: 60 Hz
- ✓ Number of phases: 3

Assigned power (ONAN): 15.000 kVA

- ✓ Nominal primary voltage: 69000 V
- ✓ Nominal secondary voltage: 6600 V
- ✓ Auxiliary voltage: 127 Vcc / 220 Vac
- ✓ Primary insulation level: LI 325 / AC 140 / Um 72.5
- ✓ Secondary insulation level: LI 60 / AC 20 / Um 7.2
- ✓ Switch location (taps): Primary
- ✓ Type of switch (taps): rechargeable, manual and automatic
- ✓ Number of stages: 21
- ✓ Tap regulation: ± 15%
- ✓ Primary terminal designation: 1U, 1V, 1W, 1N
- ✓ Secondary terminal designation: 2U, 2V, 2W, 2N
- ✓ Magnetic circuit material: Magnetic sheet, grain oriented, very low loss
- ✓ Primary and secondary windings fabrication: Cu
- ✓ Type of tank: Hot rolled steel sheet
- ✓ Vacuum supported by tank: > 1.5 times kPa
- ✓ Short-circuit impedance: 9.5%
- ✓ Guaranteed maximum noise level: IEC 60076-10 dBa

**ACCESSORIES:**

- ✓ Expansion tank
- ✓ Terminal control box
- ✓ Electrostatic screen
- ✓ Welded radiators
- ✓ Anchoring base
- ✓ Damping elements
- ✓ 90 ° bidirectional transport wheels
- ✓ Coolant emptying, filling and sampling valves
- ✓ Oil level indicator, with alarm contact
- ✓ Coolant temperature indicator, with alarm and trip devices
- ✓ Pressure release valve
- ✓ Buchholz relay
- ✓ Sudden pressure relay with alarm and trip contacts
- ✓ Temperature indicator at the hottest spot, with alarm and trip contacts
- ✓ PT100 3-wire probe (removable in each winding)
- ✓ Silicagel air dryer
- ✓ Grounding terminals
- ✓ Active part lifting of the lifting eye bolts, suspension loops and lifting hooks for the whole transformer

**DIMENSIONS AND WEIGHTS**

- ✓ Total length: 5500 m
- ✓ Total length: 5500 m
- ✓ Total height: 3500 m
- ✓ Total weight: 54000 kg
- ✓ Insulating liquid weight: 14000 kg



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### 14.5.9.3. Transformer 6.6 /.4kV0

**GENERAL INFORMATION**

- ✓ Service: Low-voltage power distribution 6.6 / 0.4 kV
- ✓ Number of equal transformers: 4

**DESIGN RESOURCES**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Outdoor maximum / minimum temperature: 30/0 ºC
- ✓ Project temperature: 40 ºC
- ✓ Relative humidity: 75%
- ✓ Installation type: outdoor
- ✓ Environmental classification: High degree of marine pollution (IV) (IEC 60815), environmental corrosivity classification C3 (ISO 9223)
- ✓ Type of construction: Oil
- ✓ Cooling: ONAN
- ✓ Group de connection: Dyn11
- ✓ Neutral grounding method: Low resistance (400 A)
- ✓ Climatic class: C1
- ✓ Environmental class: E2
- ✓ Fire behavior class: F1
- ✓ Nominal frequency: 60 Hz
- ✓ Number of phases: 3
- ✓ Assigned power (ONAN): 3500 kVA
- ✓ Nominal primary voltage: 6600 V
- ✓ Nominal secondary voltage: 400 V
- ✓ Auxiliary voltage: 127 Vdc / 220 Va
- ✓ Primary insulation level: LI 60 / AC 20 / Um 7.2
- ✓ Secondary insulation level: LI _ / AC 3 / Um 1.1
- ✓ Switch location (taps): Primary
- ✓ Type of switch: Non-rechargeable, manual
- ✓ Number of stages: 5
- ✓ Tap changer adjustment: ± 5%, ± 2.5%, 0%
- ✓ Primary terminal designation: 1U, 1V, 1W
- ✓ Secondary terminal designation: 2U, 2V, 2W, 2N
- ✓ Magnetic circuit material: Magnetic plate, grain oriented, very low loss
- ✓ Primary and secondary windings fabrication: Cu
- ✓ Type of tank: Corrugated cooling fins
- ✓ Short-circuit impedance: 7%
- ✓ Guaranteed maximum noise level: IEC 60076-10 dBa

**ACCESSORIES:**

- ✓ Expansion tank (if applicable)
- ✓ Terminal control box
- ✓ Electrostatic screen
- ✓ Welded radiators
- ✓ Anchoring base
- ✓ Damping elements
- ✓ 90 ° bidirectional transport wheels
- ✓ Drain valve
- ✓ Filling valve
- ✓ Coolant sampling valve
- ✓ Oil level indicator, with alarm contact
- ✓ Coolant temperature indicator, with alarm and trip devices
- ✓ Pressure release valve
- ✓ Buchholz relay
- ✓ Sudden pressure relay with alarm and trip contacts
- ✓ Temperature indicator at the hottest spot, with alarm and trip contacts
- ✓ PT100 3-wire probe (removable in each winding)
- ✓ Silicagel air dryer
- ✓ Grounding terminals
- ✓ Active part lifting of the lifting eye bolts, suspension loops and lifting hooks for the whole transformer
- ✓ Classification sign

**DIMENSIONS AND WEIGHTS:**

- ✓ Total length: 3200 mm
- ✓ Total length: 3200 mm
- ✓ Total height: 2950 mm
- ✓ Total weight: 1900 kg
- ✓ Insulating liquid weight: 8400 kg



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### 14.5.9.4. Motor Control Center (MCC)

**GENERAL INFORMATION**

- ✓ Service: Motor control and protection
- ✓ Number of units: MCC1 / MCC2 / MCC3 / MCC4 / MCC5 e MCC9 (according to Table A)

**DESIGN RESOURCES**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Outdoor maximum / minimum temperature: 30/0 ºC
- ✓ Projected temperature of components: 40 ºC
- ✓ Relative humidity: 75%
- ✓ Environmental classification: Marine
- ✓ Installation: Heated electrical room
- ✓ Construction standard: IEC 60439-1, 60439-2
- ✓ Operation voltage: 380 V
- ✓ Maximum service voltage: + 20%
- ✓ Insulation level: 1.1 kV
- ✓ Nominal frequency: 60 Hz
- ✓ Short circuit current (1s): According to Table A
- ✓ Neutral regime: TT
- ✓ Configuration (phases / earth / neutral) 3F + N + PE
- ✓ Voltage switching circuits: 220 V
- ✓ Voltage controlling circuits: 220 V
- ✓ Type of service: Continuous
- ✓ Installation conditions: Indoor
- ✓ Type of box: 2 mm thick galvanized steel metal sheet
- ✓ Compartments, construction model: 4b and 3b
- ✓ Type of execution: Removable
- ✓ Protection level: IP42
- ✓ Protection level against mechanical damage: 10
- ✓ Operational access: Frontal
- ✓ Cable entry: Inferior
- ✓ Cable outlet: Inferior
- ✓ Expected reserve space: 20%
- ✓ Air-conditioning system: Air
- ✓ Thermostat: Included
- ✓ Anti-condensation heater: Included
- ✓ Total column dimensions (height x depth x width): 2350x600x1100 mm
- ✓ Weight by column: 500 kg
- ✓ Main bus nominal work current: According to Table A
- ✓ Bus distribution nominal current: According to Table A
- ✓ Material, splice junction and earth main bars: Cu
- ✓ Arc-flash protection: Included
- ✓ Module identification (mimic and plate): Included
- ✓ Capacitor bank: Included

**COMPLETE EQUIPMENT:**

- ✓ Removable unit
- ✓ 4 poles
- ✓ Motorized control included
- ✓ Electronic protection relay
- ✓ Auxiliary contacts for status signal
- ✓ Trigger coil transformers
- ✓ Network analyzer
- ✓ Lightning rod class II

**COUPLING EQUIPMENT:**

- ✓ Removable unit
- ✓ 4 poles
- ✓ Motorized control included
- ✓ Electronic protection relay
- ✓ Auxiliary contacts for status signal
- ✓ Trigger coil transformers

**DIRECT OUTPUT EQUIPMENT**

- ✓ Removable unit
- ✓ 3 poles
- ✓ Door switch control
- ✓ Auxiliary contacts for status signal
- ✓ Auxiliary relays



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- ✓ Differential relay
- ✓ Toroidal transformer
- ✓ Thermal protection relay
- ✓ Thermal relay reset
- ✓ Control circuit protection
- ✓ Position switch on the door
- ✓ Status signage on the door
- ✓ Module identification on the door

**EQUIPMENT DE SAÍDA INVERTERDA VOLTA:**

- ✓ Removable unit
- ✓ 3 poles
- ✓ Door switch control
- ✓ Auxiliary contacts for status signal
- ✓ Auxiliary relays
- ✓ Differential relay
- ✓ Toroidal transformer
- ✓ Thermal protection relay
- ✓ Thermal relay reset
- ✓ Control circuit protection
- ✓ Position switch on the door
- ✓ Status signage on the door
- ✓ Module identification on the door

**SOFT STARTER OUTPUT EQUIPMENT:**

- ✓ Removable unit
- ✓ 3 poles
- ✓ Door switch control
- ✓ Auxiliary contacts for status signal
- ✓ Auxiliary relays
- ✓ Differential relay
- ✓ Toroidal transformer
- ✓ Control circuit protection
- ✓ Position switch on the door
- ✓ Status signage on the door
- ✓ Module identification on the door

**FREQUENCY VARIATION OUTPUT EQUIPMENT:**

- ✓ Removable unit
- ✓ 3 poles
- ✓ Door switch control
- ✓ Auxiliary contacts for status signal
- ✓ Auxiliary relays
- ✓ Differential relay
- ✓ Toroidal transformer
- ✓ Control circuit protection
- ✓ Position switch on the door
- ✓ Status signage on the door
- ✓ Module identification on the door

**TETRAPOLAR, TRIPOLAR OR BIPOLAR OUTPUT EQUIPMENT:**

- ✓ Removable unit
- ✓ 3 poles
- ✓ Door switch control
- ✓ Auxiliary contacts for status signal
- ✓ Auxiliary relays
- ✓ Differential relay
- ✓ Toroidal transformer
- ✓ Control circuit protection
- ✓ Position switch on the door
- ✓ Status signage on the door
- ✓ Module identification on the door

**COMMUNICATION:**

- ✓ MCC internal communication bus
- ✓ Communication interface
- ✓ PROFIBUS Communication Protocol
- ✓ Communication port RS-232
- ✓ Communication port RS-485

**PROTECTION INPUT SWITCH:**

- ✓ Instantaneous overcurrent



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- ✓ Permanent overcurrent
- ✓ Neutral instantaneous overcurrent
- ✓ Neutral permanent overcurrent

**MOTOR PROTECTIONS:**

- ✓ Thermal overload
- ✓ Locked rotor
- ✓ Phase loss
- ✓ Current unbalance
- ✓ Phase reversal
- ✓ High or low intensity
- ✓ Lack of grounding
- ✓ Motor temperature
- ✓ High or low voltage

**MEASUREMENTS**

- ✓ Measurements
- ✓ Intensity
- ✓ Voltage
- ✓ Frequency
- ✓ Motor temperature
- ✓ Active power
- ✓ Reactive power
- ✓ Power factor
- ✓ Active energy
- ✓ Reactive energy



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**TABLE A**

| MCC | MCC DATA | MCCs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CURRENT AND CUTOFF | ITEM Nº | DESCRIPTION | INSTALLED UNIT STAND-BY | INSTALLED UNIT OPER. | VOLTAGE | POWER | Protection current | TYPE OF DRIVE | NOTES |
| | A / kA | | | | | V. | kW | A | | |
| MCC3 | 5000 A 80kA | 3.01 | BAP BOOSTER PUMP | 0 | 4 | 380 | 315.00 | 400 | VDF | |
| | | 3.02 | MOTOR PUMP SUCTION AND DISCHARGE | 0 | 8 | 380 | 0.55 | 2 | INVERTER DRIVE | |
| | | 4.02 | SUCTION AND DISCHARGE VALVE | 0 | 8 | 380 | 0.55 | 2 | INVERTER DRIVE | |
| | | 4.03 | RECIRCULATION PUMPS | 0 | 4 | 380 | 315.00 | 400 | VDF | |
| | | 4.04 | SUCTION AND DISCHARGE VALVE | 0 | 8 | 380 | 0.55 | 2 | INVERTER DRIVE | |
| MCC4 | 5000 A 80kA | 7.01 | PRODUCT WATER PUMPS | 1 | 4 | 380 | 160.00 | 400 | SOFT STARTER | |
| | | | CTB-SA1 Circuit | 1 | 1 | 380 | - | 1600 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | MCC2 Circuit | 1 | 1 | 380 | - | 800 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | MCC5 Circuit | 1 | 1 | 380 | - | 800 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | MCC6 Circuit | 1 | 1 | 380 | - | 100 | | SWITCHB. OUTPUT 3F+N+PE |
| MCC5 | 800 A 50 kA | 9.01 | CHEMICAL CLEANING MOTOR PUMP | 0 | 2 | 380 | 160.00 | 400 | SOFT STARTER | |
| | | 9.05 | HEATING RESISTANCE | 0 | 1 | 380 | 280.00 | 630 | | SWITCHB. OUTPUT 3F+N+PE |
| MCC2 | 800 A 50 kA | 11.03 | BLOWER SILENCER | 1 | 2 | 380 | 1.10 | 3 | DIRECT | |
| | | 8.01 | FILTER BACKWASHING PUMP | 1 | 2 | 380 | 200.00 | 630 | SOFT STARTER | |
| | | 8.02 | FILTER BACKWASH BLOWER | 1 | 2 | 380 | 75.00 | 250 | SOFT STARTER | |
| MCC1 | 32 A 40 kA | 12.1 | SULFURIC ACID DOSING PUMP | 1 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.2 | SODIUM HYPOCHLORITE DOSING PUMP | 1 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.3 | SODIUM METABISULFITE DOSING PUMP | 1 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.4 | FERRIC CHLORIDE DOSING PUMP | 1 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.5 | DISPERSANT DOSING PUMP | 1 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.37 | DOSING PUMP SWITCHBOARDS | 0 | 1 | 250 | 8.50 | 25 | | SWITCHB. OUTPUT 3F+N+PE |
| MCC6 | 100 A 40 kA | 12.9 | CALCIUM HYDROXIDE DOSING PUMP | 1 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.10 | SODIUM FLUOROSILICATE DOSING PUMP | 1 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.11 | SODIUM HYPOCHLORITE DOSING PUMP | 1 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.22 | SULFURIC ACID TRANSFER PUMP | 1 | 1 | 380 | 5.50 | 16 | DIRECT | |
| | | 12.23 | SODIUM HYPOCHLORIDE TRANSFER PUMP | 0 | 2 | 380 | 0.37 | 2 | DIRECT | |
| | | 12.24 | SODIUM METABISULFITE AGITATOR | 0 | 1 | 380 | 1.50 | 6 | DIRECT | |

**TABLE A**

| MCC | MCC DATA | MCCs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CURRENT AND CUTOFF | ITEM Nº | DESCRIPTION | INSTALLED UNIT STAND-BY | INSTALLED UNIT OPER. | VOLTAGE | POWER | Protection current | TYPE OF DRIVE | NOTES |
| | A / kA | | | | | V. | kW | A | | |
| | | 12.25 | FERRIC CHLORIDE TRANSFER PUMP | 0 | 1 | 380 | 5.50 | 16 | DIRECT | |
| | | 12.26 | DISPERSANT AGITATOR | 0 | 2 | 380 | 0.55 | 2 | DIRECT | |
| | | 12.27 | CARBON DIOXIDE EVAPORATOR | 0 | 1 | 380 | 15.00 | 40 | SOFT STARTER | |
| | | 12.28 | CALCIUM HYDROXIDE TANK SYSTEM | 0 | 1 | 380 | 1.50 | 6 | DIRECT | |
| | | 12.29 | SODIUM FLUOROSILICATE AGITATOR | 0 | 1 | 380 | 0.55 | 2 | DIRECT | |
| | | 12.37 | DOSING PUMP SWITCHBOARDS | 0 | 1 | 250 | 5.00 | 16 | | SWITCHB. OUTPUT 3F+N+PE |
| | | 13.03 | POWDER DOSING SCREW | 1 | 1 | 380 | 0.37 | 2 | DIRECT | |

### 14.5.9.5. Low Voltage Distribution Board

**GENERAL INFORMATION**

- ✓ Service: Motor control and protection
- ✓ Number of units: CBT-SA1 e CBT-SA2 (according to Table b)

**DESIGN RESOURCES**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Outdoor maximum / minimum temperature: 30/0 ºC
- ✓ Project temperature of components: 40 ºC
- ✓ Relative humidity: 75%
- ✓ Environmental classification: marine
- ✓ Installation: heated electrical room
- ✓ Construction standard IEC 60439-1, 60439-2
- ✓ Operation voltage: 380 V
- ✓ Maximum service voltage: + 20%
- ✓ Insulation level: 1,1 kV
- ✓ Nominal Frequency: 60 Hz
- ✓
- ✓ Neutral regime: TT
- ✓ Configuration (phases / earth / neutral) 3F + N + PE



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- ✓ Switch circuit voltage: 220 V
- ✓ Control circuit voltage: 220 V
- ✓ Type of service: Continuous
- ✓ Installation conditions: Indoor
- ✓ Type of box: 2-mm thick galvanized steel metal sheet
- ✓ Compartments, construction model: 4b e 3b
- ✓ Type of execution: removable
- ✓ Protection level: IP42
- ✓ Protection level against mechanical damage: 10
- ✓ Operational access: Frontal
- ✓ Cable entry: Inferior
- ✓ Cable outlet: Inferior
- ✓ Expected reserve space: 20%
- ✓ Air-conditioning system: air
- ✓ Thermostat: Included
- ✓ Anti-condensation heater: Included
- ✓ Total column dimensions (height x depth x width): 2350x600x1100 mm
- ✓ Weight by column: 500 kg
- ✓ Current assigned to main bus: According to Table B
- ✓ Nominal current for bus distribution: According to Table B
- ✓ Material, splice junction and earth main bars: Cu
- ✓ Arc-flash protection: Included
- ✓ Module identification (mimic and plate): Included
- ✓ Capacitor bank: Included

**COMPLETE EQUIPMENT:**

- ✓ Removable unit
- ✓ 4 poles
- ✓ Motorized control included
- ✓ Electronic protection relay
- ✓ Auxiliary contacts for status signal
- ✓ Trigger coil transformers
- ✓ Network analyzer
- ✓ Lightning rod class II

**COUPLING EQUIPMENT:**

- ✓ Removable unit
- ✓ 4 poles
- ✓ Motorized control included
- ✓ Electronic protection relay
- ✓ Auxiliary contacts for status signal
- ✓ Trigger coil transformers

**SOFT STARTER OUTPUT EQUIPMENT:**

- ✓ Removable unit
- ✓ 3 poles
- ✓ Door switch control
- ✓ Auxiliary contacts for status signal
- ✓ Auxiliary relays
- ✓ Differential relay
- ✓ Toroidal transformer
- ✓ Thermal protection relay
- ✓ Thermal relay reset
- ✓ Control circuit protection
- ✓ Position switch on the door
- ✓ Status signage on the door
- ✓ Module identification on the door

**SOFT STARTER OUTLET EQUIPMENT:**

- ✓ Removable unit
- ✓ 3 poles
- ✓ Door switch control
- ✓ Auxiliary contacts for status signal
- ✓ Auxiliary relays
- ✓ Differential relay
- ✓ Toroidal transformer
- ✓ Control circuit protection
- ✓ Position switch on the door
- ✓ Status signage on the door
- ✓ Module identification on the door



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**TETRAPOLAR, TRIPOLAR OR BIPOLAR OUTPUT EQUIPMENT:**

- ✓ Door switch control
- ✓ Auxiliary contacts for status signal
- ✓ Auxiliary relays
- ✓ Differential relay
- ✓ Toroidal transformer
- ✓ Control circuit protection
- ✓ Position switch on the door
- ✓ Status signage on the door
- ✓ Module identification on the door

**COMMUNICATION:**

- ✓ MCC internal communication bus
- ✓ Communication interface
- ✓ PROFIBUS Communication Protocol
- ✓ Communication port RS-232
- ✓ Communication port RS-485

**PROTECTION INPUT SWITCH:**

- ✓ Instantaneous overcurrent
- ✓ Permanent overcurrent
- ✓ Neutral instantaneous overcurrent
- ✓ Neutral permanent overcurrent

**MEASUREMENTS**

- ✓ Measurements
- ✓ Intensity
- ✓ Voltage
- ✓ Frequency
- ✓ Motor temperature
- ✓ Active power
- ✓ Reactive power
- ✓ Power factor
- ✓ Active energy
- ✓ Reactive energy

**TABLE B**

| QGBT / MCC | MCC DATA | MCC | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CURRENT AND CUTOFF | Nº ITEM | DESCRIPTION | INSTALLED UNITS | | VOLTAGE | POWER | CURRENT | TYPE OF DRIVE | NOTES |
| | | | | STAND-BY | OPER. | | | | | |
| | A / kA | | | | | V. | kW | A | | |
| CTB-SA2 | 160 A 40 kA | | BILGE PUMP | 1 | 1 | 380 | 45.00 | 100 | SOFT STARTER | |
| | | 1.03 | DISCHARGE VALVE | 2 | 4 | 380 | 0.37 | 2 | INVERTER DRIVE | |
| | | | INTAKE EMERGENCY LIGHTING | 0 | 1 | 380 | 0.90 | 2 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | HEATING RESISTANCE PUMPS | 0 | 1 | 380 | 0.50 | 1 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | AUXILIARY SERVICE SWITCHBOARDS | 0 | 1 | 380 | 4.41 | 10 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | PRESSURE SYSTEM | 0 | 1 | 380 | 3.00 | 6 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | INDOOR LIGHTING - INTAKE BUILDING | 0 | 1 | 380 | 0.90 | 2 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | OUTDOOR LIGHTING - INTAKE BUILDING | 0 | 1 | 380 | 10.40 | 20 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | POWER OUTLETS - INTAKE BUILDING | 0 | 1 | 380 | 29.00 | 50 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | HVAC - INTAKE BUILDING | 0 | 1 | 380 | 10.00 | 20 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | Circuit MCC1 | 0 | 1 | - | - | 32 | | |
| | | 14.01 | OVERHEAD CRANE – INTAKE BUILDING | 0 | 1 | 380 | 4.00 | 10 | | SWITCHB. OUTPUT 3F+N+PE |
| CTB-SA1 | 1600A 50kA | | UPS | 1 | 1 | 380 | 30.00 | 50 | | SWITCHB. OUTPUT 3F+N+PE |
| | | 9.03 | DISPLACEMENT PUMPS | 0 | 1 | 380 | 160.00 | 400 | SOFT STARTER | |
| | | | DC SYSTEM | 1 | 1 | 380 | 15.00 | 25 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | EMERGENCY LIGHTING SUBSTATION BUILDING | 0 | 1 | 380 | 0.72 | 2 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | EMERGENCY LIGHTING ADMINISTRATION BUILDING | 0 | 1 | 380 | 1.69 | 3 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | EMERGENCY LIGHTING OSMOSIS BUILDING | 0 | 1 | 380 | 11.40 | 20 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | HEATING RESISTANCE | 0 | 1 | 380 | 28.50 | 50 | | SWITCHB. |



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**TABLE B**

| QGBT / MCC | MCC DATA CURRENT AND CUTOFF | Nº ITEM | DESCRIPTION | INSTALLED UNITS STAND-BY | INSTALLED UNITS OPER. | VOLTAGE | POWER | CURRENT | TYPE OF DRIVE | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|
| | A / kA | | | | | V. | kW | A | | |
| | | | PUMPS | | | | | | | OUTPUT 3F+N+PE |
| | | | AUXILIARY SERVICES SWITCHBOARD | 0 | 1 | 380 | 81.94 | 125 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | LV ELECTRICAL ROOM PRESSURIZATION SYSTEM | 0 | 1 | 380 | 3.00 | 6 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | MV ELECTRICAL ROOM PRESSURIZATION SYSTEM | 0 | 1 | 380 | 3.00 | 6 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | INDOOR LIGHTING - OSMOSIS BUILDING | 0 | 1 | 380 | 11.40 | 20 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | INDOOR LIGHTING - SUBSTATION BUILDING | 0 | 1 | 380 | 0.72 | 2 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | INDOOR LIGHTING - ADMSINISTRATION BLDG. | 0 | 1 | 380 | 1.69 | 6 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | INDOOR LIGHTING - PRODUCT BUILDING | 0 | 1 | 380 | 3.30 | 6 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | OUTDOOR LIGHTING | 0 | 1 | 380 | 19.80 | 40 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | OUTDOOR LIGHTING - FILTERING AREA | 0 | 1 | 380 | 12.00 | 20 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | OUTDOOR LIGHTING - PRODUCT WATER BLDG. | 0 | 1 | 380 | 4.80 | 10 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | OUTDOOR LIGHTING - SUBSTATION BUILDING | 0 | 1 | 380 | 3.20 | 6 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | POWER OUTLETS - OSMOSIS BUILDING | 0 | 1 | 380 | 57.00 | 100 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | POWER OUTLETS SUBSTATION BUILDING | 0 | 1 | 380 | 57.00 | 100 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | POWER OUTLETS ADMINISTRATIVE BUILDING | 0 | 1 | 380 | 127.00 | 250 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | POWER OUTLETS PRODUCT BUILDING | 0 | 1 | 380 | 29.00 | 50 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | HVAC LV ELECTRICAL ROOM | 0 | 1 | 380 | 15.00 | 32 | | SWITCHB. OUTPUT 3F+N+PE |

**TABLE B**

| QGBT / MCC | MCC DATA CURRENT AND CUTOFF | Nº ITEM | DESCRIPTION | INSTALLED UNITS STAND-BY | INSTALLED UNITS OPER. | VOLTAGE | POWER | CURRENT | TYPE OF DRIVE | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|
| | A / kA | | | | | V. | kW | A | | |
| | | | HVAC MV ELECTRICAL ROOM | 0 | 1 | 380 | 30.00 | 63 | | SWITCHB. OUTPUT 3F+N+PE |
| | | 14.03 | PRODUCT WATER PUMP OVERHEAD CRANE | 0 | 1 | 380 | 5.50 | 10 | | SWITCHB. OUTPUT 3F+N+PE |
| | | 11.02 | SERVICE WATER COMPRESSOR | 1 | 1 | 380 | 4.00 | 10 | | SWITCHB. OUTPUT 3F+N+PE |
| | | 14.02 | OVERHEAD CRANE PRODUCT WATER BOOSTER PIPES | 0 | 1 | 380 | 4.00 | 10 | | SWITCHB. OUTPUT 3F+N+PE |
| | | | Circuit CTB-SA2 | | | | | 160 | | SWITCHB. OUTPUT 3F+N+PE |

### 14.5.9.6. Variable Frequency Inverter MT

**GENERAL INFORMATION**

- ✓ Service: Operation and control of seawater pumps
- ✓ Number of equal units in operation 5 (4 + 1)

**DESIGN RESOURCES**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Maximum average temperature / outside minimum: 30/0 ºC
- ✓ Relative humidity: 75%
- ✓ Installation site: Heated electrical room
- ✓ Project temperature do equipment: 40 ºC
- ✓ Environmental classification: Marine
- ✓ Nominal voltage: 6600 V
- ✓ Permissible input voltage variation: +/- 10%
- ✓ Number of phases: 3
- ✓ Nominal frequency: 60 Hz
- ✓ Permissible input frequency variation: +/- 2%
- ✓ Neutral grounding: Grounding
- ✓ Short-circuit level: 25 kA



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- ✓ Type of load: Squirrel cage motor, 710 kW, motor standard model, 1000 r.p.m., clockwise
- ✓ Input switching element: Switch
- ✓ Semiconductor protection fuses: Included
- ✓ AC voltage control: 220 Vac
- ✓ CC voltage control: 127 Vcc
- ✓ Auxiliary power (control, maneuvers, heating resistance do motor, etc.): 0.3 kVA
- ✓ Rectifier module technology: Diodos
- ✓ Rectifier module pulse number: 24
- ✓ Inverter module technology: IGBT
- ✓ Brake chopper: Included
- ✓ Inverter contactor countdown: Included
- ✓ Tropicalized range: Included
- ✓ Transitory overload capacity/ s: 150%
- ✓ Permanent overload capacity: 120%
- ✓ Output frequency range max/min: 120/30%
- ✓ Efficiency: 0,97%
- ✓ Power factor: 0,98
- ✓ EMC Filter: Included
- ✓ Harmonic filter: Included
- ✓ Total harmonic distortion (THD): <5%
- ✓ Harmonic distortion voltage (THDu): IEC519
- ✓ Current harmonic distortion (THDi): IEC519
- ✓ Filter limit for dv / dt output: If applicable
- ✓ Shielded cable in motor: If applicable
- ✓ Guaranteed maximum noise level: <85 dBa
- ✓ Heating resistance: Included
- ✓ Type of cooling: Air
- ✓ Extraction of hot air outside the room: Yes, applicable
- ✓ Isolation transformer: Dry, integrated, 60 Hz, primary voltage 6,6 kV secondary voltage 6.6 kV
- ✓ Protection level VDF: IP42
- ✓ Cabinet access: Frontal
- ✓ Cable entry: Inferior
- ✓ Cable outlet: Inferior

**VARIATOR PROTECTIONS:**

- ✓ Fast-acting input fuses
- ✓ Overcurrent
- ✓ Power semiconductor overload
- ✓ Input phase loss
- ✓ High inlet voltage
- ✓ Low inlet voltage
- ✓ Bus voltage limit
- ✓ Low bus voltage
- ✓ High feed frequency
- ✓ Low feed frequency
- ✓ Temperature of power semiconductors
- ✓ Cooling temperature
- ✓ Feed source failure
- ✓ Software and hardware failure
- ✓ Lack of grounding
- ✓ Loss of analog signal inputs

**MOTOR PROTECTIONS:**

- ✓ Locked rotor
- ✓ Short circuit
- ✓ Phase loss
- ✓ Motor overload
- ✓ Voltage and phase current imbalance
- ✓ Motor overheating (PTC)
- ✓ Velocity limit
- ✓ Torque limit

**COMMUNICATION:**

- ✓ Integrated configuration panel
- ✓ Alphanumeric display
- ✓ Communication interface
- ✓ PROFIBUS Communication Protocol



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- ✓ Communication port RS-232
- ✓ Communication port RS-485
- ✓ Expansion of optional cards
- ✓ Temperature sensor winding connection (PT-100)

### 14.5.9.7. BT Variable Frequency Inverter

**GENERAL INFORMATION**

- ✓ Service: Drive and control the booster motor pumps for pressure and recirculation pumps.
- ✓ Number of equal units in operation 8

**CONFIGURATION**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Maximum / minimum outdoors temperature range: 30/0 ºC
- ✓ Relative humidity: 75%
- ✓ Installation site: Heated electrical room
- ✓ Equipment project temperature: 40 ºC
- ✓ Environmental classification: marine
- ✓ Nominal voltage: 380 V
- ✓ Permissible input voltage variation: +/- 10%
- ✓ Number of phases: 3
- ✓ Nominal frequency: 60 Hz
- ✓ Permissible input frequency variation: +/- 2%
- ✓ Neutral grounding: Grounding
- ✓ Short-circuit level: 80 kA
- ✓ Type of load: Squirrel cage motor, 315 kW, standard motor construction, 1500 r.p.m., clockwise
- ✓ Input switching element: Switch
- ✓ Semiconductor protection fuses: Included
- ✓ AC voltage control: 220 Vac
- ✓ CC voltage control: 127 Vcc
- ✓ Auxiliary power (control, maneuvers, motor heating resistance, etc.): 0.3 kVA
- ✓ Rectifier module technology IGTB
- ✓ Rectifier module pulse number 6 (low harmonic content)
- ✓ Inverter module technology: IGBT
- ✓ Brake chopper Included
- ✓ Inverter contactor countdown: Included
- ✓ Tropicalized range: Included
- ✓ Transitory overload capacity/ s: 150%
- ✓ Permanent overload capacity: 120%
- ✓ Output frequency range max/min 120/30%
- ✓ Efficiency 0,97%
- ✓ Power factor 0,98
- ✓ EMC Filter: Included
- ✓ Harmonic filter: Included
- ✓ Total harmonic distortion (THD): <5% (PCC)
- ✓ Harmonic distortion voltage (THDu): IEC519
- ✓ Current harmonic distortion (THDi): IEC519
- ✓ Dv / dt output filter limit: If applicable
- ✓ Shielded cable in motor: If applicable
- ✓ Guaranteed maximum noise level: <85 dBa
- ✓ Heating resistance: Included
- ✓ Type of cooling: Air
- ✓ VFD Protection level: IP42
- ✓ Cabinet access: Frontal
- ✓ Cable entry: Inferior
- ✓ Cable outlet: Inferior

**VARIATOR PROTECTIONS:**

- ✓ Fast-acting input fuses
- ✓ Overcurrent
- ✓ Power semiconductor overload
- ✓ Input phase loss
- ✓ High inlet voltage
- ✓ Low inlet voltage
- ✓ Bus voltage limit
- ✓ Low bus voltage
- ✓ High feed frequency
- ✓ Low feed frequency
- ✓ Power semiconductor temperature



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- ✓ Cooling temperature
- ✓ Feed source failure
- ✓ Software and hardware failure
- ✓ Lack of grounding
- ✓ Loss of analog signal inputs

**MOTOR PROTECTIONS:**

- ✓ Locked rotor
- ✓ Short circuit
- ✓ Phase loss
- ✓ Overload do motor
- ✓ Voltage and phase current imbalance
- ✓ Motor overheating (PTC)
- ✓ Velocity limit
- ✓ Torque limit

**COMMUNICATION:**

- ✓ Integrated configuration panel
- ✓ Alphanumeric display
- ✓ Communication interface
- ✓ PROFIBUS Communication Protocol
- ✓ Communication port RS-232
- ✓ Communication port RS-485
- ✓ Expansion of optional cards
- ✓ Temperature sensor winding connection (PT-100)

### 14.5.9.8. Soft Starter BT

**GENERAL INFORMATION**

- ✓ Service: Motor drive
- ✓ Number of equal drives in operation:

| Equipment | Unit | Power (kW) |
|---|---|---|
| BILGE PUMP | 1 | 45.00 |
| CHEMICAL CLEANING PUMPS | 2 | 160.00 |
| DISPLACEMENT PUMPS | 1 | 160.00 |
| PRODUCT WATER PUMP | 5 | 160.00 |
| FILTER BACKWASHING PUMPS | 3 | 200.00 |
| FILTER BACKWASHING BLOWER | 3 | 75.00 |
| CARBON DIOXIDE EVAPORATOR | 1 | 15.00 |

**DESIGN RESOURCES**

- ✓ Altitude: <= 1000 m.s.n.m.
- ✓ Outdoor maximum / minimum temperature: 30/0 ºC
- ✓ Relative humidity: 75%
- ✓ Installation site: Heated electrical room
- ✓ Environmental classification: Marine
- ✓ Nominal voltage: 380 V
- ✓ Permissible input voltage variation: ± 20 %%
- ✓ Number of phases: 3
- ✓ Nominal frequency: 60Hz
- ✓ Permissible input frequency variation: ± 5%
- ✓ Short-circuit level: 80 kA
- ✓ Type of load: Squirrel cage motor, standard model, Class F.
- ✓ Service: Heavy continuous
- ✓ Motor service factor: 1,15
- ✓ Design standard: IEC60947-4-2
- ✓ Electronic technology: Thyristors
- ✓ Start capacity: 10 No. / hours
- ✓ Bypass: Included (failure AS)
- ✓ Voltage tap contactors: LC1 D
- ✓ Control voltage: 220 V
- ✓ Tropicalized range: Included
- ✓ Air-conditioning system: Air
- ✓ Type of cabinet / assembly: Power ≥ 110 kW self-supporting metal / removable.
  Power <110kW integrated to the MCC
- ✓ Compartments: None


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- ✓ Protection level: IP54
- ✓ Cabinet access: Frontal
- ✓ Cable entry: Inferior
- ✓ Cable outlet: Inferior

**PROTECTIONS:**

- ✓ Overvoltage
- ✓ Voltage imbalance
- ✓ Current
- ✓ DC voltage
- ✓ Current imbalance
- ✓ Low current
- ✓ Low voltage
- ✓ Overload
- ✓ Short circuit
- ✓ Phase reversal
- ✓ Input phase loss
- ✓ Power semiconductors overheating
- ✓ Power semiconductor overload
- ✓ Lack of grounding
- ✓ Programming failure
- ✓ Communication failure
- ✓ Excessive motor startups / hour
- ✓ Locked rotor
- ✓ Motor overload
- ✓ Motor overheating (PTC)

**COMMUNICATION:**

- ✓ Integrated configuration panel
- ✓ Alphanumeric display
- ✓ Communication interface RS485
- ✓ PROFIBUS Communication Protocol
- ✓ Communication port RS-232
- ✓ Communication port RS-485
- ✓ Connection to the temperature sensor windings (PTC-100)
- ✓ Lighting status sensor
- ✓ Control switches
- ✓ Boot mode switch

### 14.5.9.9. Capacitor Bank BT

**GENERAL INFORMATION**

- ✓ Service: Low voltage reactive compensation
- ✓ Number of equal equipment in operation:

| BT TABLE | | SELECTED CAPACITY |
|---|---|---|
| Item | DESCRIPTION | kVAr |
| CTB-SA2 | COMPLEMENTARY SEAWATER SERVICES | 25.00 |
| CTB-SA1 | COMPLEMENTARY OSMOSIS SERVICES | 50.00 |
| MCC2 | MM FILTER BACKWASHING | 220.00 |
| MCC5 | CHEMICAL CLEANING | 50.00 |
| MCC6 | CHEMICAL DOSING | 16.00 |
| MCC4 | PRODUCT WATER PUMPING | 200.00 |

**DESIGN RESOURCES**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Outdoor maximum / minimum temperature: 30/0 ºC
- ✓ Relative humidity: 75%
- ✓ Installation site: Heated electrical room
- ✓ Type: Adjustable
- ✓ Project, construction and safety standard: IEC 61921
- ✓ Operation voltage: 380 V
- ✓ Number of phases: 3
- ✓ Nominal frequency: 60 Hz
- ✓ Frequency variation: ± 5%



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- ✓ Grounding: Landed
- ✓ Short-circuit level: 80 - 50 - 40 kA
- ✓ Auxiliary control voltage: 230 V
- ✓ Maximum THDu: 6%
- ✓ Maximum THDi: 25%
- ✓ Type of cabinet: Self-supporting metal
- ✓ Compartments: No
- ✓ Modular / expandable: No
- ✓ Protection level: IP54
- ✓ Cooling: Air
- ✓ Cable inlet / outlet: Inferior

**CONDENSER CHARACTERISTICS:**

- ✓ Capacitor connection: Triangle
- ✓ Bank model: Cylindrical
- ✓ Dielectric material: Metalized PP
- ✓ Impregnation without PCB Yes
- ✓ Impregnation type: Capacitor connection
- ✓ Self-healing: Yes
- ✓ Useful life: 130000 h. aprox.
- ✓ Capacity tolerance: -0.5%
- ✓ Overload allowed: 1,1
- ✓ Allowed overcurrent: 1.8 In
- ✓ Harmonic reaction response: Yes
- ✓ Reject filter frequency: 189 Hz
- ✓ L tolerance: 0%
- ✓ Reactor core saturation intensity: 1.2In

**REGULATOR CHARACTERISTICS:**

- ✓ Automatic operation / manual and local / remote switch
- ✓ Measurements and alarms display
- ✓ Stage connection indication
- ✓ Alarm indicator

**ASSEMBLY AND PROTECTIONS:**

- ✓ Automatic input switch
- ✓ Voltage presence indicator (active line)
- ✓ Control voltage transformer
- ✓ Step protection fuses
- ✓ Connection contactors
- ✓ Overpressure disconnector
- ✓ Discharge resistance

**COMMUNICATION:**

- ✓ Communication interface
- ✓ PROFIBUS Communication Protocol
- ✓ Communication port RS-232
- ✓ Communication port RS-485
- ✓ Power factor measurement
- ✓ Power factor not reached alarm
- ✓ Excessive temperature alarm
- ✓ Overpressure alarm
- ✓ Fuse trip alarm

### 14.5.9.10. Uninterruptible Power Supply (UPS)

**GENERAL INFORMATION**

- ✓ Service: Emergency AC power
- ✓ Number of equal units in operation: 2 (1 + 1)

**DESIGN RESOURCES**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Outdoor maximum / minimum temperature: 30/0 ºC
- ✓ Relative humidity: 85%
- ✓ Installation site: Heated electrical room
- ✓ Type: Anti-seismic
- ✓ Input nominal voltage: 380Vac
- ✓ Number of input phases: 3
- ✓ Input voltage range: -10% + 15%



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- ✓ Feed frequency: 60 Hz
- ✓ Feed frequency variator: 10%
- ✓ Output voltage: 380 Vac
- ✓ Number of outlet phases: 3
- ✓ Nominal voltage: 30 kVA
- ✓ Autonomy with 100% charge: 60 min
- ✓ Autonomy with 50% charge: > 120 Min
- ✓ Full-charge efficiency: 88%
- ✓ Short circuit current: 40 kA
- ✓ Harmonic distortion (THDv) with linear load: <3%
- ✓ Harmonic distortion (THDV) with non-linear load: 3%
- ✓ Noise level at 1m: 65 dBa
- ✓ Type of cabinet: Self-supporting
- ✓ Cabinet material: Steel
- ✓ Protection level: IP32
- ✓ Cabinet access: Frontal
- ✓ Cable inlet / outlet: Inferior
- ✓ Temperature regulation: Yes
- ✓ Air-conditioning system: Forced

**RECTIFIER MODULE CHARACTERISTICS:**

- ✓ Technology type / rectifier: Tiristor
- ✓ Redundant: Yes
- ✓ Isolation transformer: Yes
- ✓ Charging time: 8 h
- ✓ Rectifier outlet nominal voltage: 220 Vcc
- ✓ Nominal rectification current: 45 A
- ✓ Floating load voltage: 240,80 Vcc
- ✓ Curling da output voltage: 2%
- ✓ Battery charging limit: Capacity / 10 A

**INVERTER MODULE CHARACTERISTICS:**

- ✓ Technology type / inverter: IGBT
- ✓ Redundant: Yes
- ✓ Output voltage variation (0-100% of load): 2%
- ✓ Output voltage variation as a function of input voltage: 1%
- ✓ Time supported at overload: 150% 1 min
- ✓ Time supported at overload: 125% 1 min
- ✓ Time supported at overload: 120% 10 min
- ✓ Type of battery / technology: NiCd
- ✓ Battery life: 20 years
- ✓ Filling interval: 5 years
- ✓ Number of elements: 172
- ✓ Redundant capacitor bank: Yes
- ✓ Float voltage: 1.40 Vcc / element
- ✓ Fast charging voltage: 1.45 Vcc / element
- ✓ End cell voltage: 1.02 Vcc / element
- ✓ Charge / discharge cycle: 60 min
- ✓ Type / electrolyte recipient material: polypropylene
- ✓ Battery case: Anti-seismic design
- ✓ Protection level: IP00

**TRANSFER SYSTEM CHARACTERISTICS:**

- ✓ Automatic bypass switch: Yes
- ✓ Microprocessor control: Yes
- ✓ Overload: 500% - 10 ms
- ✓ Manual bypass switch: Yes
- ✓ Manual bypass switch type: Before interval
- ✓ Transformer bypass: Yes
- ✓ Bypass transformer type: Capacitor connection
- ✓ Bypass isolation transformer class: H

**PROTECTIONS:**

- ✓ AC voltage
- ✓ DC voltage
- ✓ Low AC voltage



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- ✓ Low DC voltage
- ✓ Overload
- ✓ Short circuit
- ✓ Maximum current batteries
- ✓ Current charger maximum input
- ✓ No ground connection
- ✓ No feed current

**COMMUNICATION:**

- ✓ Integrated configuration panel
- ✓ Alarm contacts
- ✓ Communication interface
- ✓ PROFIBUS Communication Protocol
- ✓ Communication port RS-232
- ✓ Communication port RS-485

### 14.5.9.11. Direct current system (DC)

**GENERAL INFORMATION**

- ✓ Service: Trustworthy and uninterrupted power supply
- ✓ Number of equal units in operation: 2

**DESIGN RESOURCES**

- ✓ Altitude: <1000 m.s.n.m.
- ✓ Outdoor maximum / minimum temperature: 30/0 ºC
- ✓ Relative humidity: 75%
- ✓ Installation site: Heated electrical room
- ✓ Environmental classification: Marine
- ✓ Type: Anti-seismic
- ✓ Input nominal voltage: 3x380 V
- ✓ Number of input phases: 3
- ✓ Input voltage range: ± 10%
- ✓ Feed frequency: 60 Hz
- ✓ Feed frequency variator: 10%
- ✓ Output voltage: 127 Vcc
- ✓ Input power factor: 0.8
- ✓ Autonomy with 100% charge: 480 min
- ✓ Autonomy with 50% charge: 960 min
- ✓ Full charge efficiency (AC / DC): 90%
- ✓ Short circuit current: 40 kA
- ✓ Insulation level: 2500 V
- ✓ Neutral grounding system: TI
- ✓ Noise level: 65 dBa
- ✓ Type of cabinet: self-supporting
- ✓ Cabinet material: Steel
- ✓ Protection level: IP20
- ✓ Cabinet access: Frontal
- ✓ Cable inlet / outlet: Inferior
- ✓ Temperature regulation: Yes
- ✓ Air-conditioning system: Forced
- ✓ Technology type / rectifier: Thyristors
- ✓ Redundant: Yes
- ✓ Isolation transformer: Yes
- ✓ Rectifier outlet nominal voltage: 127 Vcc
- ✓ Nominal rectification current: 150 A
- ✓ Output voltage curling: 1%
- ✓ Battery charging limit: Capacity / 10 A

**ACCUMULATOR BANK CHARACTERISTICS**

- ✓ Type of battery / technology: NiCd
- ✓ Capacity: 550 Ah
- ✓ Battery life: 20 years
- ✓ Filling interval: 5 years
- ✓ Number of elements: 94
- ✓ Redundant capacitor bank: Yes
- ✓ Float voltage: 1.40 Vcc / element
- ✓ Equalizing voltage: 1.45 Vcc / element



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- ✓ Floating current: <1,5 A
- ✓ Equalizing current: 55 A
- ✓ End cell voltage: 1.13 Vcc
- ✓ Battery case: Anti-seismic design
- ✓ Protection level: IP00

**PROTECTIONS:**

- ✓ AC voltage
- ✓ DC voltage
- ✓ Low AC voltage
- ✓ Low DC voltage
- ✓ Overload
- ✓ Short circuit
- ✓ Battery Current Limit
- ✓ Charger input current limiting
- ✓ No ground connection
- ✓ No feed current

**COMMUNICATION**

- ✓ Integrated configuration panel
- ✓ Alarm contacts
- ✓ PROFIBUS Communication Protocol
- ✓ Communication port RS-232
- ✓ Communication port RS-485

### 14.5.10. SIP Recirculating Pumps

**GENERAL DATA**

- ✓ Service: SIP recirculation pumping
- ✓ Type of drive Electric motor with VFD
- ✓ Number of equal pumps in operation 4
- ✓ Number of equal pumps in reserve 0

**DESIGN CHARACTERISTICS**

- ✓ Flow at predetermined site m3/h 1,091
- ✓ Projected TDH m.c.l. 68.5
- ✓ Suction pressure at predetermined site barg 57.5
- ✓ Room temperature ºC 40-20
- ✓ Seawater maximum temperature ºC 30
- ✓ Seawater minimum temperature ºC 22
- ✓ Construction model Horizontal, between bearings
- ✓ Number of stages 1
- ✓ Type of impeller Simple suction
- ✓ Impeller design Closed
- ✓ Type of body Surface
- ✓ Body division Radial
- ✓ Body assembly Center line
- ✓ Rotation direction (view from motor) Clockwise
- ✓ Bearing model lifespan h. 60,000
- ✓ Nº de RTD/Pt-100 by bearing 1
- ✓ Type of motor coupling Flexible

**OPERATION CHARACTERISTICS**

- ✓ Normal work flow m3/h 1,091
- ✓ Maximum expected work flow m3/h 1,200
- ✓ Minimum expected work flow m3/h 982
- ✓ TDH at normal flow m.c.l. 68.5
- ✓ Minimum TDH at minimum flow m.c.l. 35
- ✓ Suction pressure bar 57.5
- ✓ Pump performance with regular flow % 83
- ✓ Power demanded by pump kW 252
- ✓ Noise level in normal operation (incl. Motor) dB 85

**MATERIALS DA PUMP**

- ✓ Body Superduplex PREN >40
- ✓ Impeller Superduplex PREN >40
- ✓ Axis Superduplex PREN >40
- ✓ Axis housing Superduplex PREN >40

### 14.5.11. Chemical Cleaning Pumps/Displacement

**GENERAL INFORMATION**

- ✓ Service: Chemical cleaning/displacement pumping
- ✓ Type of drive Soft starter


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- ✓ Number of equal pumps in operation 2
- ✓ Number of equal pumps in reserve 1

**DESIGN CHARACTERISTICS**

- ✓ Flow at predetermined site m3/h 565
- ✓ Projected TDH m.c.l. 64.06
- ✓ Suction pressure at predetermined site barg 0,07
- ✓ Room temperature ºC 40-20
- ✓ Seawater maximum temperature ºC 30
- ✓ Seawater minimum temperature ºC 22
- ✓ Construction model Horizontal, between bearings
- ✓ Number of stages 1
- ✓ Type of impeller Simple suction
- ✓ Impeller design Closed
- ✓ Type of body Surface
- ✓ Body division Radial
- ✓ Body assembly Center line
- ✓ Rotation direction (view from motor) Clockwise
- ✓ Bearing model lifespan h. 60,000
- ✓ Nº de RTD/Pt-100 by bearing 1
- ✓ Type of motor coupling Flexible

**OPERATION CHARACTERISTICS**

- ✓ Normal work flow m3/h 565
- ✓ Maximum expected work flow m3/h 622
- ✓ Minimum expected work flow m3/h 509
- ✓ TDH at normal flow m.c.l. 64.06
- ✓ Minimum TDH at minimum flow m.c.l. 35
- ✓ Suction pressure bar 0.07
- ✓ Pump performance with regular flow % 80
- ✓ Power demanded by pump kW 127
- ✓ Noise level in normal operation (incl. Motor) dB 85

**PUMP MATERIAL**

- ✓ Body AISI 316
- ✓ Impeller AISI 316
- ✓ Axis AISI 316
- ✓ Axis housing AISI 316

## 14.5.12. Chemical Cleaning and Agitation Pumps

**GENERAL INFORMATION**

- ✓ Service: Agitation and chemical cleaning pumping
- ✓ Type of drive Soft starter
- ✓ Number of equal pumps in operation 2
- ✓ Number of equal pumps in reserve 0

**DESIGN CHARACTERISTICS**

- ✓ Flow at predetermined site m3/h 550
- ✓ Projected TDH m.c.l. 5.68
- ✓ Suction pressure at predetermined site barg 0.07
- ✓ Room temperature ºC 40-20
- ✓ Seawater maximum temperature ºC 30
- ✓ Seawater minimum temperature ºC 22
- ✓ Construction model Horizontal, between bearings
- ✓ Number of stages 1
- ✓ Type of impeller Simple suction
- ✓ Impeller design Closed
- ✓ Type of body Surface
- ✓ Body division Radial
- ✓ Body assembly Center line
- ✓ Rotation direction (view from motor) Clockwise
- ✓ Bearing model lifespan h. 60,000
- ✓ Nº de RTD/Pt-100 by bearing 1
- ✓ Type of motor coupling Flexible

**OPERATION CHARACTERISTICS**

- ✓ Normal work flow m3/h 550
- ✓ Maximum expected work flow m3/h 605
- ✓ Minimum expected work flow m3/h 495
- ✓ TDH at normal flow m.c.l. 5.68
- ✓ Minimum TDH at minimum flow m.c.l. 3
- ✓ Suction pressure bar 0.07



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- ✓ Pump performance with regular flow % 75
- ✓ Power demanded by pump kW 12
- ✓ Noise level in normal operation (incl. Motor) dB 85

**PUMP MATERIAL**

- ✓ Body AISI 316
- ✓ Impeller AISI 316
- ✓ Axis AISI 316
- ✓ Axis housing AISI 316

### 14.5.13. Product water pumps

**GENERAL INFORMATION**

- ✓ Service: Product water pumping
- ✓ Type of drive Soft starter
- ✓ Number of equal pumps in operation 4
- ✓ Number of equal pumps in reserve 1

**DESIGN CHARACTERISTICS**

- ✓ Flow at predetermined site m3/h 900
- ✓ Projected TDH m.c.l. 76.20
- ✓ Suction pressure at predetermined site bar -0,01
- ✓ Room temperature ºC 40-20
- ✓ Seawater maximum temperature ºC 30
- ✓ Seawater minimum temperature ºC 22
- ✓ Construction model Horizontal, between bearings
- ✓ Number of stages 1
- ✓ Type of impeller Simple suction
- ✓ Impeller design Closed
- ✓ Type of body Surface
- ✓ Body division Radial
- ✓ Body assembly Center line
- ✓ Rotation direction (view from motor) Clockwise
- ✓ Bearing model lifespan h. 60,000
- ✓ Nº de RTD/Pt-100 by bearing 1
- ✓ Type of motor coupling Flexible

**OPERATION CHARACTERISTICS**

- ✓ Normal work flow m3/h 900
- ✓ Maximum expected work flow m3/h 990
- ✓ Minimum expected work flow m3/h 810
- ✓ TDH at normal flow m.c.l. 76.20
- ✓ Minimum TDH at minimum flow m.c.l. 20
- ✓ TDH a Maximum expected work flow m.c.l.
- ✓ Suction pressure bar 0
- ✓ Pump performance with regular flow % 85
- ✓ Power demanded by pump kW 295
- ✓ Noise level in normal operation (incl. Motor) dB 85

**PUMP MATERIAL**

- ✓ Body AISI 316
- ✓ Impeller AISI 316
- ✓ Axis AISI 316
- ✓ Axis housing AISI 316

### 14.5.14. Chemical Dosing Pumps

#### 14.5.14.1. Group 1: Pre-treatment Sodium Hypochlorite Dosage

**PUMP GENERAL INFORMATION**

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 3 (2+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid Sodium Hypochlorite
- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC
- ✓ Density 1.32 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation's nominal flow 334 L/h
- ✓ Maximum flow 500 L/h
- ✓ Minimum flow (10% of max) 50 L/h
- ✓ Pressure de discharge a maximum flow 8 barg
- ✓ Voltage absorbed by pump 0.37 KW
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %



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- ✓ Type of regulation — Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system — Oil

**MATERIALS**

- ✓ Injector body — PVC or similar
- ✓ Ball guides — PVC or similar
- ✓ Seats — PVC or similar
- ✓ Ball valves — Glass, ceramics
- ✓ Connection — PVC or similar
- ✓ Membrane — PTFE
- ✓ Joints — Viton
- ✓ Spring-loaded ball valves — Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped with servomotor — Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage — 400 V.
- ✓ Feed frequency — 50 Hz.
- ✓ Feed — 3-phase
- ✓ Motor nominal voltage — 0.37 KW
- ✓ Type of protection — IP-55
- ✓ Type of insulation — Class F
- ✓ Drive — Direct

**SERVOMOTOR**

- ✓ Feed voltage — 230 V.
- ✓ Feed frequency — 50 Hz.
- ✓ Feed — Single-phase
- ✓ Nominal voltage — 0.37 KW
- ✓ Type of protection — IP-65
- ✓ Control signal — 4-20 mA
- ✓ Feedback signal — 4-20 mA
- ✓ Local position sensor — Yes

### 14.5.14.2. Group 2: Pre-treatment Sodium Hypochlorite Dosage

**PUMP GENERAL INFORMATION**

- ✓ Type of pump — Hydraulic command membrane pumps
- ✓ Number of equal pumps — 3 (2+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid — Sodium Hypochlorite
- ✓ Maximum fluid temperature — 25 ºC
- ✓ Minimum fluid temperature — 15 ºC
- ✓ Density — 1.32 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation's nominal flow — 15 L/h
- ✓ Maximum flow — 30 L/h
- ✓ Minimum flow (10% of max) — 3,0 L/h
- ✓ Suction pressure — Atmospheric bar
- ✓ Pressure de discharge a maximum flow — 8 bar
- ✓ Voltage absorbed by pump — 0.37 KW
- ✓ Regulation — 10-100 %
- ✓ Regulation accuracy — ±2 %
- ✓ Type of regulation — Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system — Oil

**MATERIALS**

- ✓ Injector body — PVC or similar
- ✓ Ball guides — PVC or similar
- ✓ Seats — PVC or similar
- ✓ Ball valves — Glass, ceramics
- ✓ Connection — PVC or similar
- ✓ Membrane — PTFE
- ✓ Joints — Viton
- ✓ Spring-loaded ball valves — Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped with servomotor — Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage — 400 V.
- ✓ Feed frequency — 50 Hz.
- ✓ Feed — 3-phase
- ✓ Motor nominal voltage — 0.37 KW



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- ✓ Type of protection IP-55
- ✓ Type of insulation Class F
- ✓ Drive Direct

**SERVOMOTOR**

- ✓ Feed voltage 230 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0.37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.14.3. Group 3: Pre-treatment Sulfuric Acid Dosage

**PUMP GENERAL INFORMATION**

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 3 (2+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid Sulfuric acid
- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC
- ✓ Density 1,84 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation's nominal flow 18 L/h
- ✓ Maximum flow 40 L/h
- ✓ Minimum flow (10% of max) 50 L/h
- ✓ Suction pressure Atmospheric bar
- ✓ Pressure de discharge a maximum flow 8 bar
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %
- ✓ Type of regulation Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system Oil

**MATERIALS**

- ✓ Injector body AISI 316 L
- ✓ Ball guides AISI 316 L
- ✓ Seats AISI 316 L
- ✓ Ball valves Glass, ceramics
- ✓ Connection AISI 316 L
- ✓ Membrane PTFE
- ✓ Joints Viton
- ✓ Spring-loaded ball valves Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped with servomotor Yes
- ✓ Nominal motor operating conditions:
- ✓ Feed voltage 400 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed 3-phase
- ✓ Motor nominal voltage 0,37 KW
- ✓ Type of protection IP-55
- ✓ Type of insulation Class F
- ✓ Drive Direct

**SERVOMOTOR**

- ✓ Feed voltage 230 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0.37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.14.4. Group 4: Sulfuric Acid Dosage for Neutralization/Chemical Cleaning

**PUMP GENERAL INFORMATION**

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 2 (1+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid Sulfuric acid



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- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC
- ✓ Density 1.84 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation's nominal flow 334 L/h
- ✓ Maximum flow 500 L/h
- ✓ Minimum flow (10% of max) 50 L/h
- ✓ Suction pressure Atmospheric bar
- ✓ Pressure de discharge a maximum flow 8 bar
- ✓ Voltage absorbed by pump 0,37 KW
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %
- ✓ Type of regulation Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system Oil

**MATERIALS**

- ✓ Injector body AISI 316 L
- ✓ Ball guides AISI 316 L
- ✓ Seats AISI 316 L
- ✓ Ball valves Glass, ceramics
- ✓ Connection AISI 316 L
- ✓ Membrane PTFE
- ✓ Joints Viton
- ✓ Spring-loaded ball valves Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped with servomotor Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage 400 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed 3-phase
- ✓ Motor nominal voltage 0.37 KW
- ✓ Type of protection IP-55
- ✓ Type of insulation Class F
- ✓ Drive Direct

**SERVOMOTOR**

- ✓ Feed voltage 230 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0.37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.14.5. Group 5: Pretreatment Sodium Metabisulfite Dosage

**PUMP GENERAL INFORMATION**

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 3 (2+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid Sodium Metabisulfite
- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC
- ✓ Density 1.48 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation's nominal flow 119 L/h
- ✓ Maximum flow 150 L/h
- ✓ Minimum flow (10% of max) 15 L/h
- ✓ Suction pressure Atmospheric bar
- ✓ Maximum discharge pressure 8 bar
- ✓ Voltage absorbed by pump 0.37 KW
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %
- ✓ Type of regulation Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system Oil

**MATERIALS**

- ✓ Injector body PVC or similar
- ✓ Ball guides PVC or similar
- ✓ Seats PVC or similar



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- ✓ Ball valves — Glass, ceramics
- ✓ Connection — PVC or similar
- ✓ Membrane — PTFE
- ✓ Joints — Viton
- ✓ Spring-loaded ball valves — Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped with servomotor — Yes
- ✓ Nominal motor operating conditions:
- ✓ Feed voltage — 400 V.
- ✓ Feed frequency — 50 Hz.
- ✓ Feed — 3-phase
- ✓ Motor nominal voltage — 0.37 KW
- ✓ Type of protection — IP-55
- ✓ Type of insulation — Class F
- ✓ Drive — Direct

**SERVOMOTOR**

- ✓ Feed voltage — 230 V.
- ✓ Feed frequency — 50 Hz.
- ✓ Feed — Single-phase
- ✓ Nominal voltage — 0.37 KW
- ✓ Type of protection — IP-65
- ✓ Control signal — 4-20 mA
- ✓ Feedback signal — 4-20 mA
- ✓ Local position sensor — Yes

### 14.5.14.6. Group 6: Ferric chloride dosage

**PUMP GENERAL INFORMATION**

- ✓ Type of pump — Hydraulic command membrane pumps
- ✓ Number of equal pumps — 3 (2+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid — Ferric chloride
- ✓ Maximum fluid temperature — 25 ºC
- ✓ Minimum fluid temperature — 15 ºC
- ✓ Density — 1.42 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation’s nominal flow — 40 L/h
- ✓ Maximum flow — 60 L/h
- ✓ Minimum flow (10% of max) — 6.0 L/h
- ✓ Suction pressure — Atmospheric bar
- ✓ Maximum discharge pressure — 8 bar
- ✓ Voltage absorbed by pump — 0.37 KW
- ✓ Regulation — 10-100 %
- ✓ Regulation accuracy — ±2 %
- ✓ Type of regulation — Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system — Oil

**MATERIALS**

- ✓ Injector body — PVC or similar
- ✓ Ball guides — PVC or similar
- ✓ Seats — PVC or similar
- ✓ Ball valves — Glass, ceramics
- ✓ Connection — PVC or similar
- ✓ Membrane — PTFE
- ✓ Joints — Viton
- ✓ Spring-loaded ball valves — Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped with servomotor — Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage — 400 V.
- ✓ Feed frequency — 50 Hz.
- ✓ Feed — 3-phase
- ✓ Motor nominal voltage — 0.37 KW
- ✓ Type of protection — IP-55
- ✓ Type of insulation — Class F
- ✓ Drive — Direct

**SERVOMOTOR**

- ✓ Feed voltage — 230 V.



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- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0.37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.14.7. Group 7: Dispersant Dosage

**PUMP GENERAL INFORMATION**

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 3 (2+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid Dispersant
- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC
- ✓ Density 1,0 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation's nominal flow 4 L/h
- ✓ Maximum flow 10 L/h
- ✓ Minimum flow (10% of max) 1.0 L/h
- ✓ Suction pressure Atmospheric bar
- ✓ Maximum discharge pressure 8 bar
- ✓ Voltage absorbed by pump 0,37 KW
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %
- ✓ Type of regulation Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system Oil

**MATERIALS**

- ✓ Injector body PVC or similar
- ✓ Ball guides PVC or similar
- ✓ Seats PVC or similar
- ✓ Ball valves Glass, ceramics
- ✓ Connection PVC or similar
- ✓ Membrane PTFE
- ✓ Joints Viton
- ✓ Spring-loaded ball valves Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped with servomotor Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage 400 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed 3-phase
- ✓ Motor nominal voltage 0.37 KW
- ✓ Type of protection IP-55
- ✓ Type of insulation Class F
- ✓ Drive Direct

**SERVOMOTOR**

- ✓ Feed voltage 230 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0.37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.14.8. Group 8: Post-treatment Powder Activated Carbon Dosage

**PUMP GENERAL INFORMATION**

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 3 (2+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid Activated carbon
- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC
- ✓ Density 2.0 Kg/L

**PUMP OPERATING CONDITIONS**



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- ✓ Operation’s nominal flow 80 L/h
- ✓ Maximum flow 160 L/h
- ✓ Minimum flow (10% of max) 16.0 L/h
- ✓ Suction pressure Atmospheric bar
- ✓ Maximum discharge pressure 8 bar
- ✓ Voltage absorbed by pump 0.37 KW
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %
- ✓ Type of regulation Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system Oil

**MATERIALS**

- ✓ Injector body PVC or similar
- ✓ Ball guides PVC or similar
- ✓ Seats PVC or similar
- ✓ Ball valves Glass, ceramics
- ✓ Connection PVC or similar
- ✓ Membrane PTFE
- ✓ Joints Viton
- ✓ Spring-loaded ball valves Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped com servo-motor Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage 400 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed 3-phase
- ✓ Motor nominal voltage 0.37 KW
- ✓ Type of protection IP-55
- ✓ Type of insulation Class F
- ✓ Drive Direct

**SERVOMOTOR**

- ✓ Feed voltage 230 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0.37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.14.9. Group 9: Post-treatment CO2 Dosage

**PUMP GENERAL INFORMATION**

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 2 (1+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid Carbon dioxide
- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC
- ✓ Pure product dose 35 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation’s nominal flow 126 kg/h
- ✓ Maximum flow 250 kg/h
- ✓ Minimum flow (10% of max) 25.0 L/h
- ✓ Suction pressure Atmospheric bar
- ✓ Maximum discharge pressure 8 bar
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %
- ✓ Type of regulation Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system Oil

**MATERIALS**

- ✓ Injector body PVC or similar
- ✓ Ball guides PVC or similar
- ✓ Seats PVC or similar
- ✓ Ball valves Glass, ceramics
- ✓ Connection PVC or similar
- ✓ Membrane PTFE
- ✓ Joints Viton
- ✓ Spring-loaded ball valves Hastelloy C



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GENERAL MOTOR INFORMATION

- ✓ Equipped with servomotor Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage 400 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed 3-phase
- ✓ Motor nominal voltage 3 KW
- ✓ Type of protection IP-55
- ✓ Type of insulation Class F
- ✓ Drive Direct

SERVOMOTOR

- ✓ Feed voltage 230 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0.37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.14.10. Group 10: Post-treatment Calcium hydroxide Dosage

PUMP GENERAL INFORMATION

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 5 (4+1) Units

CHARACTERISTICS OF THE FLUID TO BE DOSED

- ✓ Type of fluid Calcium hydroxide (lime)
- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC

PUMP OPERATING CONDITIONS

- ✓ Operation’s nominal flow 8 L/h
- ✓ Maximum flow 351 L/h
- ✓ Minimum flow (10% of max) 450 L/h
- ✓ Suction pressure Atmospheric bar
- ✓ Maximum discharge pressure 120 bar
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %
- ✓ Type of regulation Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system Oil

MATERIALS

- ✓ Injector body PVC or similar
- ✓ Ball guides PVC or similar
- ✓ Seats PVC or similar
- ✓ Ball valves Glass, ceramics
- ✓ Connection PVC or similar
- ✓ Membrane PTFE
- ✓ Joints Viton
- ✓ Spring-loaded ball valves Hastelloy C

GENERAL MOTOR INFORMATION

- ✓ Equipped with servomotor Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage 400 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed 3-phase
- ✓ Motor nominal voltage 2.5 KW
- ✓ Type of protection IP-55
- ✓ Type of insulation Class F
- ✓ Drive Direct

SERVOMOTOR

- ✓ Feed voltage 230 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0,37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.14.11. Group 11: Sodium Fluorosilicate Dosage



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**PUMP GENERAL INFORMATION**

- ✓ Type of pump Hydraulic command membrane pumps
- ✓ Number of equal pumps 3 (2+1) Units

**CHARACTERISTICS OF THE FLUID TO BE DOSED**

- ✓ Type of fluid Sodium Fluorosilicate
- ✓ Maximum fluid temperature 25 ºC
- ✓ Minimum fluid temperature 15 ºC
- ✓ Density 1,00 Kg/L

**PUMP OPERATING CONDITIONS**

- ✓ Operation's nominal flow 18 L/h
- ✓ Maximum flow 40 L/h
- ✓ Minimum flow (10% of max) 4,0 L/h
- ✓ Suction pressure Atmospheric bar
- ✓ Maximum discharge pressure 8 bar
- ✓ Voltage absorbed by pump 0,37 KW
- ✓ Regulation 10-100 %
- ✓ Regulation accuracy ±2 %
- ✓ Type of regulation Automatic 4-20 mA with position feedback 4-10 mA
- ✓ Lubrification system Oil

**MATERIALS**

- ✓ Injector body PVC or similar
- ✓ Ball guides PVC or similar
- ✓ Seats PVC or similar
- ✓ Ball valves Glass, ceramics
- ✓ Connection PVC or similar
- ✓ Membrane PTFE
- ✓ Joints Viton
- ✓ Spring-loaded ball valves Hastelloy C

**GENERAL MOTOR INFORMATION**

- ✓ Equipped with servomotor Yes
- ✓ Nominal motor operating conditions
- ✓ Feed voltage 400 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed 3-phase
- ✓ Motor nominal voltage 0,22 KW
- ✓ Type of protection IP-55
- ✓ Type of insulation Class F
- ✓ Drive Direct

**SERVOMOTOR**

- ✓ Feed voltage 230 V.
- ✓ Feed frequency 50 Hz.
- ✓ Feed Single-phase
- ✓ Nominal voltage 0.37 KW
- ✓ Type of protection IP-65
- ✓ Control signal 4-20 mA
- ✓ Feedback signal 4-20 mA
- ✓ Local position sensor Yes

### 14.5.15. Metal Tanks

**GENERAL INFORMATION:**

- ✓ Service: Storage - Sulfuric acid
- ✓ Number of tanks 2

**FLUID CHARACTERISTICS**:

- ✓ Type of fluid: Sulfuric acid
- ✓ Concentration: % 98
- ✓ Density: kg/L 1,84 kg/l
- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS**:

- ✓ Design code: ASME Sac. VIII, Div. 1 or similar
- ✓ Project pressure barg Full + 0.5 mcl
- ✓ Pressure proof barg According to design code
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code



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- ✓ Head thickness: mm According to design code
- ✓ Extra thickness for corrosion: Yes
- ✓ Reservoir unit capacity (useful volume): m3 6

**RESERVOIR CHARACTERISTICS**:

- ✓ Type: Cylindrical with Korbbogen head (horizontal or vertical, as advised by manufacturer)
- ✓ Installation: Outdoors
- ✓ Design and construction for a useful life of: 25 years
- ✓ Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES:**

- ✓ Lifting Eye Bolts (yes/no): yes
- ✓ Bench anchoring system: yes
- ✓ Characteristics plate yes
- ✓ Grounding system yes
- ✓ Manway access cover yes
- ✓ Stairs, handrails, platforms, etc.: yes (if needed)
- ✓ Metal support for agitator with anti-corrosion coat no
- ✓ Equipped with electric agitator no

**CONNECTIONS (Type, DN and PN/Schedule)**

- ✓ Reactive load input (superior head): 1 unit DN-80 PN-10
- ✓ Common suction pumps: 1 unit DN-25 PN-10
- ✓ Level transmitter

  (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-10
- ✓ Manway access cover 1 unit DN-600 PN-10
- ✓ Ventilation: 1 unit DN-80 PN-10
- ✓ Overflow: 1 unit DN-80 PN-10
- ✓ Drainage: 1 unit DN-80 PN-10

**MATERIALS**:

- ✓ Body and heads: S 275
- ✓ Flanges: RSt 37.2
- ✓ Interior lining: no
- ✓ Exterior painting: sandblasting at SA-2 ½, application of a 100-micron epoxy primer coat, application of an intermediate 50-micron paint coat.

## 14.5.16. GRP Tanks

### 14.5.16.1. Pre-treatment Sodium Hypochlorite Tanks

**GENERAL INFORMATION:**

- ✓ Service: Sodium Hypochlorite storage
- ✓ Number of tanks 2

**FLUID CHARACTERISTICS:**

- ✓ Type of fluid: Sodium Hypochlorite
- ✓ Concentration: % 16
- ✓ Density: kg/L 1.24 kg/l
- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS**:

- ✓ Project pressure barg Full of water + 0.5 mcl
- ✓ Pressure proof barg Complete water seal
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code
- ✓ Head thickness: mm According to design code
- ✓ Reservoir unit capacity (useful volume): m3 1

**RESERVOIR CHARACTERISTICS**:

- ✓ Type: Vertical cylinder, plain base
- ✓ Superior head: With opening and pumping capabilities
- ✓ Installation: Exterior
- ✓ Design and construction for a useful life of: years 25
- ✓ Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES**:

- ✓ Lifting Eye Bolts (yes/no): yes
- ✓ Bench anchoring system: yes
- ✓ Stairs, handrails, platforms, etc.: yes
- ✓ Metal support for agitator with anti-corrosion coat no
- ✓ Equipped with electric agitator no

**CONNECTIONS (Type, DN and PN/Schedule)**



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- ✓ Reactive load input (superior head): 1 unit DN-80 PN-10
- ✓ Common suction pumps: 1 unit DN-25 PN-6
- ✓ Level transmitter (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- ✓ Manway access cover 1 unit DN-600 PN-6
- ✓ Ventilation: 1 unit DN-25 PN-6
- ✓ Overflow: 1 unit DN-80 PN-6
- ✓ Drainage: 1 unit DN-80 PN-6

**MATERIALS**:

- ✓ Body and heads: GRP
- ✓ Mechanic reinforcement: Orthophthalic resin
- ✓ Chemical barrier: Vinyl resin
- ✓ UV radiation protection yes

### 14.5.16.2. Ferric Chloride Tanks

**GENERAL INFORMATION**:

- ✓ Service: Storage Ferric chloride
- ✓ Number of tanks 2

**FLUID CHARACTERISTICS:**

- ✓ Type of fluid: Ferric chloride
- ✓ Concentration: %
- ✓ Density: kg/L 1.42 kg/l
- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS**:

- ✓ Project pressure: barg Full of water + 0,5 mcl
- ✓ Pressure proof: barg Tightness (full of water)
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code
- ✓ Head thickness: mm According to design code
- ✓ Reservoir unit capacity (useful volume): m3 30

**RESERVOIR CHARACTERISTICS**:

- ✓ Type: Vertical cylinder, plain base
- ✓ Superior head: With opening and pumping capabilities
- ✓ Installation: Exterior
- ✓ Design and construction for a useful life of: years 25
- ✓ Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES:**

- ✓ Lifting Eye Bolts (yes/no): yes
- ✓ Bench anchoring system: yes
- ✓ Stairs, handrails, platforms, etc.: yes
- ✓ Metal support for agitator with anti-corrosion coat no
- ✓ Equipped with electric agitator no

**CONNECTIONS (Type, DN e PN/Schedule)**

- ✓ Reactive load input (superior head): 1 unit DN-80 PN-10
- ✓ Common suction pumps: 1 unit DN-25 PN-6
- ✓ Level transmitter (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- ✓ Manway access cover: 1 unit DN-600 PN-6
- ✓ Ventilation: 1 unit DN-25 PN-6
- ✓ Overflow: 1 unit DN-80 PN-6
- ✓ Drainage: 1 unit DN-80 PN-6

**MATERIALS**:

- ✓ Body and heads: GRP
- ✓ Mechanic reinforcement: Orthophthalic resin
- ✓ Chemical barrier: Vinyl resin
- ✓ UV radiation protection yes

### 14.5.16.3. Sodium Metabisulfite Tanks

**GENERAL INFORMATION**:

- ✓ Service: Sodium metabisulfite solution
- ✓ Number of tanks 2

**FLUID CHARACTERISTICS**:

- ✓ Type of fluid: Sodium metabisulfite
- ✓ Density: kg/L 1.2 kg/l



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- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS:**

- ✓ Project pressure: barg Full of water + 0,5 mcl
- ✓ Pressure proof: barg Tightness (full of water)
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code
- ✓ Head thickness: mm According to design code
- ✓ Reservoir unit capacity (useful volume): m3 1

**RESERVOIR CHARACTERISTICS:**

- ✓ Type: Vertical cylinder, plain base
- ✓ Superior head: Plain, with opening and electric agitator capabilities
- ✓ Installation: Exterior
- ✓ Design and construction for a useful life of: years 25
- ✓ Design and construction for a continuous operation of: h/year 8.600

**ACCESSORIES**:

- ✓ Lifting Eye Bolts (yes/no): yes
- ✓ Bench anchoring system: yes
- ✓ Stairs, handrails, platforms, etc.: yes
- ✓ Metal support for agitator with anti-corrosion coat yes
- ✓ Equipped with electric agitator yes

**CONNECTIONS (Type, DN e PN/Schedule)**

- ✓ Service water inlet (superior head): 1 unit DN-50 PN-10
- ✓ Common suction pumps: 1 unit DN-25 PN-6
- ✓ Level transmitter
  (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- ✓ Ventilation: 1 unit DN-25 PN-6
- ✓ Overflow: 1 unit DN-80 PN-6
- ✓ Drainage: 1 unit DN-80 PN-6

**MATERIALS**:

- ✓ Body and heads: GRP
- ✓ Mechanic reinforcement: Orthophthalic resin
- ✓ Chemical barrier: Vinyl resin
- ✓ UV radiation protection yes

### 14.5.16.4. Dispersant Tanks

**GENERAL INFORMATION**:

- ✓ Service: Dispersant solution
- ✓ Number of tanks: 2
- ✓ Equipment tags:

**FLUID CHARACTERISTICS**:

- ✓ Type of fluid: Dispersant
- ✓ Concentration: %
- ✓ Density: kg/L 1,4 kg/l
- ✓ Viscosity: cps
- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS:**

- ✓ Project pressure: barg Full of water + 0.5 mcl
- ✓ Pressure proof: barg Tightness (full of water)
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code
- ✓ Head thickness: mm According to design code
- ✓ Reservoir unit capacity (useful volume): $m^3$ 0.5

**RESERVOIR CHARACTERISTICS**:

- ✓ Type: Vertical cylinder, plain base
- ✓ Superior head: Plain, with opening and electric agitator capabilities
- ✓ Installation: Exterior
- ✓ Design and construction for a useful life of: years 25
- ✓ Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES:**



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- ✓ Lifting Eye Bolts (yes/no): yes
- ✓ Bench anchoring system: yes
- ✓ Stairs, handrails, platforms, etc.: yes
- ✓ Metal support for agitator with anti-corrosion coat yes
- ✓ Equipped with electric agitator yes

**CONNECTIONS (Type, DN e PN/Schedule)**

- ✓ Service water inlet (superior head): 1 unit DN-50 PN-10
- ✓ Common suction pumps: 1 unit DN-25 PN-6
- ✓ Level transmitter (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- ✓ Ventilation: 1 unit DN-25 PN-6
- ✓ Overflow: 1 unit DN-80 PN-6
- ✓ Drainage: 1 unit DN-80 PN-6

**MATERIALS**:

- ✓ Body and heads: GRP
- ✓ Mechanic reinforcement: Orthophthalic resin
- ✓ Chemical barrier: Vinyl resin
- ✓ UV radiation protection yes

### 14.5.16.5. Sodium fluorosilicate Tanks

**GENERAL INFORMATION:**

- ✓ Service: Sodium fluorosilicate solution
- ✓ Number of tanks 2
- ✓ Equipment tags:

**FLUID CHARACTERISTICS:**

- ✓ Type of fluid: Sodium fluorosilicate
- ✓ Concentration: %
- ✓ Density: kg/L 1.2 kg/l
- ✓ Viscosity: cps
- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS:**

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS:**

- ✓ Project pressure: barg Full of water + 0.5 mcl
- ✓ Pressure proof: barg Tightness (full of water)
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code
- ✓ Head thickness: mm According to design code
- ✓ Reservoir unit capacity (useful volume): $m^3$ 1

**RESERVOIR CHARACTERISTICS**:

- ✓ Type: Vertical cylinder, plain base
- ✓ Superior head: Plain, with opening and electric agitator capabilities
- ✓ Installation: Exterior
- ✓ Design and construction for a useful life of: years 25
- ✓ Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES:**

- ✓ Lifting Eye Bolts (yes/no): yes
- ✓ Bench anchoring system: yes
- ✓ Stairs, handrails, platforms, etc.: yes
- ✓ Metal support for agitator with anti-corrosion coat yes
- ✓ Equipped with electric agitator yes

**CONNECTIONS (Type, DN e PN/Schedule)**

- ✓ Service water inlet (superior head): 1 unit DN-50 PN-10
- ✓ Common suction pumps: 1 unit DN-25 PN-6
- ✓ Level transmitter
  (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- ✓ Ventilation: 1 unit DN-25 PN-6
- ✓ Overflow: 1 unit DN-80 PN-6
- ✓ Drainage: 1 unit DN-80 PN-6

**MATERIALS**:

- ✓ Body and heads: GRP
- ✓ Mechanic reinforcement: Orthophthalic resin
- ✓ Chemical barrier: Vinyl resin
- ✓ UV radiation protection yes

### 14.5.16.6. Post-treatment Sodium Hypochlorite Tanks



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**GENERAL INFORMATION**:

- ✓ Service: Storage - Sodium Hypochlorite
- ✓ Number of tanks 2
- ✓ Equipment tags:

**FLUID CHARACTERISTICS**:

- ✓ Type of fluid: Sodium Hypochlorite
- ✓ Concentration: %
- ✓ Density: kg/L 1.24 kg/l
- ✓ Viscosity: cps
- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS**:

- ✓ Project pressure barg Full of water + 0.5 mcl
- ✓ Pressure proof barg Tightness (full of water)
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code
- ✓ Head thickness: mm According to design code
- ✓ Reservoir unit capacity (useful volume): $m^3$ 12

**RESERVOIR CHARACTERISTICS**:

- ✓ Type: Vertical cylinder, plain base
- ✓ Superior head: With opening and pumping capabilities
- ✓ Installation: Exterior
- ✓ Design and construction for a useful life of: years 25
- ✓ Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES**:

- ✓ Lifting Eye Bolts (yes/no): yes
- ✓ Bench anchoring system: yes
- ✓ Stairs, handrails, platforms, etc.: yes
- ✓ Metal support for agitator with anti-corrosion coat no
- ✓ Equipped with electric agitator no

**CONNECTIONS (Type, DN e PN/Schedule)**

- ✓ Reactive load input (superior head): 1 unit DN-80 PN-10
- ✓ Common suction pumps: 1 unit DN-25 PN-6
- ✓ Level transmitter (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- ✓ Manway access cover 1 unit DN-600 PN-6
- ✓ Ventilation: 1 unit DN-25 PN-6
- ✓ Overflow: 1 unit DN-80 PN-6
- ✓ Drainage: 1 unit DN-80 PN-6

**MATERIALS:**

- ✓ Body and heads: GRP
- ✓ Mechanic reinforcement: Orthophthalic resin
- ✓ Chemical barrier: Vinyl resin
- ✓ UV radiation protection yes

### 14.5.16.7. Lime Tanks

**GENERAL INFORMATION:**

- ✓ Service: Storage - Lime
- ✓ Number of tanks 2

**FLUID CHARACTERISTICS:**

- ✓ Type of fluid: Lime
- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS:**

- ✓ Project pressure: barg Full of water + 0.5 mcl
- ✓ Pressure proof: barg Tightness (full of water)
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code
- ✓ Head thickness: mm According to design code
- ✓ Reservoir unit capacity (useful volume): m3 7.10

**RESERVOIR CHARACTERISTICS**:



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- Type: Vertical cylinder, plain base
- Superior head: With opening and pumping capabilities
- Installation: Exterior
- Design and construction for a useful life of: years 25
- Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES:**

- Lifting Eye Bolts (yes/no): yes
- Bench anchoring system: yes
- Stairs, handrails, platforms, etc.: yes
- Metal support for agitator with anti-corrosion coat no
- Equipped with electric agitator yes

**CONNECTIONS (Type, DN e PN/Schedule)**

- Reactive load input (superior head): 1 unit DN-80 PN-10
- Common suction pumps: 1 unit DN-25 PN-6
- Level transmitter
  (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- Manway access cover 1 unit DN-600 PN-6
- Ventilation: 1 unit DN-25 PN-6
- Overflow: 1 unit DN-80 PN-6
- Drainage: 1 unit DN-80 PN-6

**MATERIALS:**

- Body and heads: GRP
- Mechanic reinforcement: Orthophthalic resin
- Chemical barrier: Vinyl resin
- UV radiation protection yes

### 14.5.17. Displacement Water Tanks

**GENERAL INFORMATION**:

- Service: Storage - displacement water
- Number of tanks 1
- Equipment tags:

**FLUID CHARACTERISTICS**:

- Type of fluid: Permeate water
- Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- Temperature ° C 20-40
- Humidity 75 %
- Annual precipitation 133 mm
- Wind
- Seismic coefficient

**DESIGN CONDITIONS**:

- Design code:
- Project pressure: barg Full of water + 0.5 mcl
- Pressure proof: barg Tightness full of water
- Work pressure: barg Atmospheric
- Body thickness: mm According to design code
- Head thickness: mm According to design code
- Reservoir unit capacity (useful volume): m3 200

**RESERVOIR CHARACTERISTICS**:

- Type: Vertical cylinder, plain base
- Superior head: With opening and pumping capabilities
- Installation: Exterior
- Design and construction for a useful life of: years 25
- Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES**:

- Lifting Eye Bolts (yes/no): yes
- Bench anchoring system: yes
- Stairs, handrails, platforms, etc.: yes
- Metal support for agitator with anti-corrosion coat no
- Equipped with electric agitator no

**CONNECTIONS (Type, DN e PN/Schedule)**

- Reactive load input (superior head): 1 unit DN-80 PN-10
- Common suction pumps: 1 unit DN-25 PN-6
- Level transmitter (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- Manway access cover 1 unit DN-600 PN-6
- Ventilation: 1 unit DN-25 PN-6



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- ✓ Overflow: 1 unit DN-80 PN-6
- ✓ Drainage: 1 unit DN-80 PN-6

**MATERIALS**:

- ✓ Body and heads: GRP
- ✓ Mechanic reinforcement: Orthophthalic resin
- ✓ Chemical barrier: Vinyl resin
- ✓ UV radiation protection yes

### 14.5.18. Calcium Hydroxide Reservoirs

**GENERAL INFORMATION:**

- ✓ Service: Storage - Calcium hydroxide
- ✓ Number of tanks 2

**FLUID CHARACTERISTICS**:

- ✓ Type of fluid: Calcium hydroxide
- ✓ Maximum temperature: ° C 40

**ENVIRONMENTAL CONDITIONS**:

- ✓ Temperature ° C 20-40
- ✓ Humidity 75 %
- ✓ Annual precipitation 133 mm

**DESIGN CONDITIONS**:

- ✓ Project pressure: barg Full of water + 0.5 mcl
- ✓ Pressure proof: barg Tightness (full of water)
- ✓ Work pressure: barg Atmospheric
- ✓ Body thickness: mm According to design code
- ✓ Head thickness: mm According to design code
- ✓ Reservoir unit capacity (useful volume): $m^3$ 100

**RESERVOIR CHARACTERISTICS**:

- ✓ Type: Vertical cylinder, plain base
- ✓ Superior head: With opening and pumping capabilities
- ✓ Installation: Exterior
- ✓ Number of dosage screws Units 2
- ✓ Capacity of each dosage screw Kg/h 138.86
- ✓ Design and construction for a useful life of: 25 years
- ✓ Design and construction for a continuous operation of: h/year 8,600

**ACCESSORIES**:

- ✓ Lifting Eye Bolts (yes/no): yes
- ✓ Bench anchoring system: yes
- ✓ Stairs, handrails, platforms, etc.: yes
- ✓ Metal support for agitator with anti-corrosion coat no

**CONNECTIONS (Type, DN e PN/Schedule)**

- ✓ Reactive load input (superior head): 1 unit DN-80 PN-10
- ✓ Common suction pumps: 1 unit DN-25 PN-6
- ✓ Level transmitter (installed near the bottom of the tank, measured by a water column): 1 unit DN-80 PN-6
- ✓ Manway access cover: 1 unit DN-600 PN-6
- ✓ Ventilation: 1 unit DN-25 PN-6
- ✓ Overflow: 1 unit DN-80 PN-6
- ✓ Drainage: 1 unit DN-80 PN-6

**MATERIALS**:

- ✓ Body and heads: Carbon steel
- ✓ Abrasive jet SA. 2.5
- ✓ Chemical barrier: Epoxy resin, 80 micra
- ✓ Finish Polyurethane 35 micra



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## 14.6. Seawater Analysis

Results of analyzes carried out in January 2020 at ten points, five around the intake area and five around the discharge area (outfall), collected close to the surface and close to the bottom.

| Parameters | Intake - Botton | | | Intake - Surface | | | Outfall - Botton | | | Outfall - Surface | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average | Minimum | Maximum | Average | Minimum | Maximum | Average | Minimum | Maximum | Average | Minimum | Maximum |
| pH | 8.12 | 8.09 | 8.17 | 8.11 | 8.07 | 8.15 | 8.28 | 8.20 | 8.41 | 8.27 | 8.18 | 8.41 |
| Temperature (oC) | 29.1 | 29.1 | 29.1 | 28.8 | 28.7 | 28.8 | 29.1 | 29.1 | 29.1 | 28.9 | 28.9 | 28.9 |
| Salinity (psu) | 36.9 | 36.9 | 36.9 | 36.3 | 36.3 | 36.4 | 36.9 | 36.9 | 36.9 | 36.5 | 36.4 | 36.5 |
| Conductivity (µS / cm) | 60,174 | 60,121 | 60,213 | 58,954 | 58,890 | 59,064 | 60,146 | 60,094 | 60,186 | 59,282 | 59,232 | 59,365 |
| Total Organic Carbon (mg / L) | 1.3 | 1.1 | 1.4 | | | | 1.1 | 1.0 | 1.2 | | | |
| Dissolved Oxygen (mg / L) | 7.06 | 7.03 | 7.08 | 7.26 | 7.14 | 7.39 | 6.99 | 6.96 | 7.02 | 7.09 | 7.05 | 7.14 |
| Chlorophyll - a (µg / L) | 0.2 | 0.2 | 0.4 | 0.3 | 0.1 | 0.4 | 0.2 | 0.2 | 0.3 | 0.1 | 0.1 | 0.2 |
| Transparency (m) | 9.7 | 7.0 | 14.0 | | | | 12.4 | 10.0 | 14.0 | | | |
| Sedimentable Materials (mL / L) | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Hexane-Soluble Substances - Mineral Oils (mg / L) | | | | <10.00 | <10.00 | <10.00 | | | | <10.00 | <10.00 | <10.00 |
| Hexane Soluble Substances Vegetable Oils and Animal Fats (mg / L) | | | | 2.0 | 0.7 | 6.4 | | | | 0.5 | <0.2 | 0.5 |
| Apparent Color | | | | | | | <10 | <10 | <10 | | | |
| Total Suspended Solids (mg / L) | 11.4 | 9.3 | 14.3 | 11.3 | 9.6 | 13.1 | 13.1 | 11.0 | 14.5 | 11.1 | 10.3 | 11.7 |
| Calcium (mg / L) | 520.2 | 489.7 | 533.4 | | | | 528 | 506 | 575 | | | |
| Magnesium (mg / L) | 1,451 | 1,362 | 1,486 | | | | 1,463 | 1,372 | 1,586 | | | |
| Potassium (mg / L) | 443.7 | 422.8 | 456.0 | | | | 444 | 425 | 481 | | | |
| Sodium (mg / L) | 12,380 | 11,600 | 12,703 | | | | 12,433 | 11,699 | 13,481 | | | |
| Alkalinity in Bicarbonates (mg / L $HCO_3$) | 93.0 | 85.0 | 101.0 | | | | 83 | 60 | 93 | | | |
| Chlorides (mg / L) | 21,193 | 20,993 | 21,993 | | | | 21,393 | 20,993 | 21,993 | | | |
| Soluble Silica (mg / L) | | | | | | | ND | ND | ND | | | |
| SDI | 6.5 | 6.3 | 6.5 | 6.1 | 5.9 | 6.2 | | | | | | |
| Dissolved Aluminum (mg / L) | 0.1 | 0.0 | 0.1 | | | | 0.153 | 0.049 | 0.435 | | | |
| Total Arsenic (mg / L) | <0.0001 | <0.0001 | <0.0001 | | | | <0.0001 | <0.0001 | <0.0001 | | | |
| Total Barium (mg / L) | <0.0005 | <0.0005 | <0.0005 | | | | <0.0005 | <0.0005 | <0.0005 | | | |
| Total Beryllium (mg / L) | <0.0002 | <0.0002 | <0.0002 | | | | <0.0002 | <0.0002 | <0.0002 | | | |
| Boron (mg / L) | 5.5 | 5.1 | 5.8 | | | | 5.6 | 5.0 | 6.1 | | | |
| Total Cadmium (mg / L) | <0.0005 | <0.0005 | <0.0005 | | | | <0.0005 | <0.0005 | <0.0005 | | | |
| Total Lead (mg / L) | 0.002 | 0.001 | 0.004 | | | | 0.0012 | 0.0006 | 0.0024 | | | |
| Total Cyanide (mg / L) | ND | ND | ND | | | | ND | ND | ND | | | |
| Free Cyanide (mg / L) | ND | ND | ND | | | | ND | ND | ND | | | |
| Dissolved Copper (mg / L) | ND | ND | ND | | | | ND | ND | ND | | | |
| Total Chromium (mg / L) | <0.0005 | <0.0005 | <0.0005 | | | | <0.0005 | <0.0005 | <0.0005 | | | |
| Hexavalent Chromium (mg / L) | ND | ND | ND | | | | ND | ND | ND | | | |
| Trivalent Chromium (mg / L) | <0.1 | <0.1 | <0.1 | | | | <0.1 | <0.1 | <0.1 | | | |
| Total Tin (mg / L) | <0.001 | <0.001 | <0.001 | | | | <0.001 | <0.001 | <0.001 | | | |
| Dissolved Iron (mg / L) | 0.1 | 0.0 | 0.2 | | | | 0.0 | 0.0 | 0.1 | | | |
| Total Fluoride (mg / L) | 3.5 | 2.2 | 8.5 | | | | 3.4 | 2.1 | 5.2 | | | |
| Total Phosphorus (mg / L) | 0.0 | 0.0 | 0.0 | | | | 0.013 | 0.011 | 0.015 | | | |
| Total Manganese (mg / L) | <0.001 | <0.001 | <0.001 | | | | <0.001 | <0.001 | <0.001 | | | |
| Dissolved Manganese (mg / L) | ND | ND | ND | | | | ND | ND | ND | | | |
| Total Mercury (mg / L) | ND | ND | ND | | | | ND | ND | ND | | | |
| Total Nickel (mg / L) | <0.001 | <0.001 | <0.001 | | | | <0.001 | <0.001 | <0.001 | | | |
| Nitrate (mg / L) | 0.008 | 0.002 | 0.011 | | | | 0.002 | <0.002 | 0.003 | | | |
| Nitrite (mg / L) | 0.005 | <0.002 | 0.005 | | | | 0.002 | 0.001 | 0.003 | | | |
| Polyphosphates (mg / L) | <0.02 | <0.02 | <0.02 | | | | <0.02 | <0.02 | <0.02 | | | |
| Total Silver (mg / L) | ND | ND | ND | | | | ND | ND | ND | | | |
| Total Selenium (mg / L) | <0.005 | <0.005 | <0.005 | | | | <0.005 | <0.005 | <0.005 | | | |
| Sulphide (mg / L) | ND | ND | ND | | | | ND | ND | ND | | | |
| Total Thallium (mg / L) | <0.0005 | <0.0005 | <0.0005 | | | | <0.0005 | <0.0005 | <0.0005 | | | |
| Total Uranium (mg / L) | 0.003 | 0.003 | 0.003 | | | | 0.0033 | 0.0031 | 0.0035 | | | |
| Total Zinc (mg / L) | <0.05 | <0.05 | <0.05 | | | | <0.05 | <0.05 | <0.05 | | | |
| Phenol index (µg / L) | ND | ND | ND | | | | <0.1 | <0.1 | <0.1 | | | |
| C. Thermotolerants (NMP) | <1.8 | <1.8 | <1.8 | <1.8 | <1.8 | <1.8 | <1.8 | <1.8 | <1.8 | <1.8 | <1.8 | <1.8 |

ND: Não detectado pelo método.



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## 14.7. Topography Report



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## 14.8. Geotechnics Report



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## 14.9. Preliminary Bathymetry Report



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## 14.10. ART

## 14.11.



**Cagece – Companhia de Água e Esgoto do Ceará**
Av. Dr. Lauro Vieira Chaves, 1030 – Vila União
CEP: 60.420-280 - Fortaleza - CE – Brasil
Fone: (85) 3101.1719Fax: (85) 3101.1860

**Anotação de Responsabilidade Técnica - ART**
**Lei nº 6.496, de 7 de dezembro de 1977**

# CREA-CE

**ART OBRA / SERVIÇO**
**Nº CE20190567707**

**Conselho Regional de Engenharia e Agronomia do Ceará**

INICIAL

**1. Responsável Técnico**

**LIDUINO DE ALBUQUERQUE MARQUES**

Título profissional: **ENGENHEIRO CIVIL**

RNP: **0608528960**

Registro: **45474D CE**

**2. Dados do Contrato**

Contratante: **Companhia de Água e Esgoto do Ceará** CPF/CNPJ: **07.040.108/0001-57**

**AVENIDA LAURO VIEIRA CHAVES** Nº: **1030**

Complemento: Bairro: **AEROPORTO**

Cidade: **FORTALEZA** UF: **CE** CEP: **60422700**

Contrato: **Não especificado** Celebrado em: **06/12/2017**

Valor: **R$ 7.241,00** Tipo de contratante: **PESSOA JURÍDICA DE DIREITO PRIVADO**

Ação Institucional: **NENHUMA - NÃO OPTANTE**

**3. Dados da Obra/Serviço**

**RUA JOAQUIM FLORIANO** Nº: **913**

Complemento: **6º Andar** Bairro: **ITAIM BIBI**

Cidade: **SÃO PAULO** UF: **SP** CEP: **04534013**

Data de Início: **06/07/2017** Previsão de término: **31/12/2019** Coordenadas Geográficas: **0, 0**

Finalidade: **SEM DEFINIÇÃO** Código: **Não especificado**

Proprietário: **Companhia de Água e Esgoto do Ceará** CPF/CNPJ: **07.040.108/0001-57**

**4. Atividade Técnica**

| 21 - ELABORAÇÃO | Quantidade | Unidade |
|---|---|---|
| 4 - ANTEPROJETO > RESOLUÇÃO 1025 -> OBRAS E SERVIÇOS - CONSTRUÇÃO CIVIL -> OBRAS HIDRÁULICAS E RECURSOS HÍDRICOS -> #1401 - ADUÇÃO DE ÁGUA | 1,00 | un |
| 4 - ANTEPROJETO > RESOLUÇÃO 1025 -> OBRAS E SERVIÇOS - CONSTRUÇÃO CIVIL -> OBRAS HIDRÁULICAS E RECURSOS HÍDRICOS -> #1411 - ESTAÇÃO ELEVATÓRIA | 1,00 | un |
| 4 - ANTEPROJETO > RESOLUÇÃO 1025 -> OBRAS E SERVIÇOS - CONSTRUÇÃO CIVIL -> SANEAMENTO -> #1607 - ADUTORA | 1,00 | un |

Após a conclusão das atividades técnicas o profissional deverá proceder a baixa desta ART

**5. Observações**

Vinculada a ART28027230191471678-SP. Resp:Paulo Roberto de Oliveira/Título:Eng. Civil/RNP:1402093071/Emp:GSINIMA. Anteprojeto de Planta de Dessalinização com vazão de 1m3/s em Fortaleza-CE. Alterações realizadas devido a mudança do local da planta.

**6. Declarações**

- Declaro que estou cumprindo as regras de acessibilidade previstas nas normas técnicas da ABNT, na legislação específica e no decreto n. 5296/2004.

**7. Entidade de Classe**

NENHUMA - NÃO OPTANTE

**8. Assinaturas**

Declaro serem verdadeiras as informações acima

Fortaleza, 03 de Dezembro de 2019
Local data

LIDUINO DE ALBUQUERQUE MARQUES - CPF: 017.569.733-77

Companhia de Água e Esgoto do Ceará - CNPJ: 07.040.108/0001-57

Gerente de Projetos de Engenharia
GPROJ - CAGECE

**9. Informações**

* A ART é válida somente quando quitada, mediante apresentação do comprovante do pagamento ou conferência no site do Crea.

* Somente é considerada válida a ART quando estiver cadastrada no CREA, quitada, possuir as assinaturas originais do profissional e contratante.

**10. Valor**

Valor da ART: **R$ 85,96** Registrada em: **14/11/2019** Valor pago: **R$ 85,96** Nosso Número: **8213656579**

Anotação de Responsabilidade Técnica - ART
Lei nº 6.496, de 7 de dezembro de 1977
CREA-SP
Conselho Regional de Engenharia e Agronomia do Estado de São Paulo

**ART de Obra ou Serviço**
28027230191471678

### 1. Responsável Técnico

**PAULO ROBERTO DE OLIVEIRA**
Título Profissional: **Engenheiro Civil**
RNP: **1402093071**
Registro: **5060133047-SP**
Empresa Contratada: **GS INIMA BRASIL LTDA**
Registro: **0897153-SP**

### 2. Dados do Contrato

Contratante: **COMPANHIA DE ÁGUA E ESGOTO DO CEARÁ - CAGECE** CPF/CNPJ: **07.040.108/0001-57**
Endereço: **Avenida LAURO VIEIRA CHAVES** Nº: **1030**
Complemento: Bairro: **AEROPORTO**
Cidade: **Fortaleza** UF: **CE** CEP: **60422-700**
Contrato: Celebrado em: **06/12/2017** Vinculada à Art nº:
Valor: R$ **3.502.594,77** Tipo de Contratante: **Pessoa Jurídica de Direito Público**
Ação Institucional:

### 3. Dados da Obra Serviço

Endereço: **Rua JOAQUIM FLORIANO** Nº: **913**
Complemento: **6º ANDAR** Bairro: **ITAIM BIBI**
Cidade: **São Paulo** UF: **SP** CEP: **04534-013**
Data de Início: **06/12/2017**
Previsão de Término: **07/05/2018**
Coordenadas Geográficas:
Finalidade: **Saneamento básico** Código:
Proprietário: **COMPANHIA DE ÁGUA E ESGOTO DO CEARÁ - CAGECE** CPF/CNPJ: **07.040.108/0001-57**

### 4. Atividade Técnica

| | | | | Quantidade | Unidade |
|---|---|---|---|---|---|
| **Elaboração** | | | | | |
| **1** | **Anteprojeto** | **Qualidade da Água** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Adução de Água** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Captação de Água** | **Doméstica** | **1,00000** | **unidade** |
| | **Anteprojeto** | **Ensaio de Ondas** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Estação Elevatória** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Obra Subaquática** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Estação de Tratamento de Água** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Obras Submarinas** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Tratamento de Água** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Reservação de Água** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Arranjo Físico (lay-out)** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Edificação** | **Alvenaria** | **1,00000** | **unidade** |
| | **Anteprojeto** | **Relatório de Impacto Ambiental / RIMA** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Sistemas e Estações de Tratamento** | **Água** | **1,00000** | **unidade** |
| | **Anteprojeto** | **Emissário Submarino** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Adutora** | **de Água na Rede Pública** | **1,00000** | **unidade** |
| | **Anteprojeto** | **Estudo de Impacto Ambiental / EIA** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Rede de Água** | | **1,00000** | **unidade** |
| | **Anteprojeto** | **Equipamentos** | **Águas** | **1,00000** | **unidade** |

| | | | | |
|---|---|---|---|---|
| **Elaboração 1** | **Anteprojeto** | **Captação Superficial de Água** | **1,00000** | **unidade** |

Após a conclusão das atividades técnicas o profissional deverá proceder a baixa desta ART

## 5. Observações

**ART referente aos serviços de Supervisão da Elaboração dos Estudos de Viabilidade, Levantamentos, Investigações e/ou Pareceres referentes à Concepção, ao Financiamento, à Implantação/Construção e a Operação de uma Planta de Dessalinização de Água Marinha com Capacidade de 1m³/s, para a Região Metropolitana de Fortaleza, objeto do Procedimento de Manifestação de Interesse - PMI nº 01/2017/CAGECE, divididos em 15 (quinze) estudos quais sejam: Diretrizes do Projeto; Diagnóstico e Estudos de Demanda; Estudos de Alternativas de Locação; Anteprojeto de Engenharia;Estudo de Demanda e de Fornecimento de Energia Elétrica;Estudo de Impacto Ambiental; Estudos de Viabilidade; Modelagem Financeira; Modelagem Operacional; Estrutura de Financiamento e Garantias; Critérios de Desempenho e Monitoramento; Análise de Riscos e Value for Money; Modelagem Jurídica; Avaliação Institucional e Plano de Comunicação.**

## 6. Declarações

**Acessibilidade: Declaro que as regras de acessibilidade previstas nas normas técnicas da ABNT, na legislação específica e no Decreto nº 5.296, de 2 de dezembro de 2004, não se aplicam às atividades profissionais acima relacionadas.**

## 7. Entidade de Classe

**68 - SEESP - SINDICATO DOS ENGENHEIROS NO ESTADO DE SÃO PAULO - SEESP**

## 8. Assinaturas

**Declaro serem verdadeiras as informações acima**

_______________ ______ de _______________ de ________

Local data

**PAULO ROBERTO DE OLIVEIRA - CPF: 374.712.876-91**

**COMPANHIA DE ÁGUA E ESGOTO DO CEARÁ - CAGECE - CPF/CNPJ: 07.040.108/0001-57**

## 9. Informações

**- A presente ART encontra-se devidamente quitada conforme dados constantes no rodapé-versão do sistema, certificada pelo *Nosso Número*.**

**- A autenticidade deste documento pode ser verificada no site www.creasp.org.br ou www.confea.org.br**

**- A guarda da via assinada da ART será de responsabilidade do profissional e do contratante com o objetivo de documentar o vínculo contratual.**

www.creasp.org.br
Tel: 0800 17 18 11
E-mail: acessar link Fale Conosco do site acima

CREA-SP

Valor ART R$ **214,82** Registrada em: **08/11/2019** Valor Pago R$ **214,82** Nosso Numero: **28027230191471678** Versão do sistema

**Impresso em: 11/11/2019 08:32:17**

# 15. Participating Team

## 15.1. By CAGECE

The table below lists the Cagece team participating in the review and complementation of this study.

| CAGECE | |
|---|---|
| Electrical engineering | Amanda Rodrigues Rangel |
| Geoprocessing | Barbara Kelly Silva Lima Rodrigues |
| Civil Engineering | Gabriella de Souza Mendonca |
| Civil Engineering | Liduíno de Albuquerque Marques |
| Electrical Engineering | Raul Tigre de Arruda Leitão |
| Civil Engineering | Ronner Braga Gondim |
| Budgeting | Tiago Cavalcante Lima |
| Overall Coordination | Silvano Porto Pereira |

## 15.2. By the Authorized Company

The table below lists the team indicated by the Authorized Company as a participant in the execution of this study.

| GS INIMA | |
|---|---|
| General Coordinator | Eduardo Berrettini |
| Electrical Engineer | Raul Castaño |
| Electrical Engineer | Carlos Carretero |
| Automation Engineer | Albert Vazquez |
| Mechanical Engineer | Francisco Díez |
| Economist | Fernando Schlieper |
| Lawyer | Rodrigo de Pinho Bertoccellli |
| Designer | Alberto Barceló |
| Designer | Manuel Rodriguez |
| Designer | Lola López |
| Responsible for the process | David Gonzales |
| Responsible for pre-treatment | Almudena Aparicio |
| Coastal and Maritime Works Manager | Alberto Casado |
| Responsible for Submarine Outfall | Enrique de la Plata |
| Responsible for SQMA | Cristina San Miguel Avedillo |
| Responsible for Energy Efficiency | Luis Miguel Garcia |
| Responsible for Marine Hydrodynamics | Mario Sanchez |
| Technical Operational Studies Coordinator | Adriana Lucas Alcaraz Lopez |
| Process Engineer | Anna Gironés |
| Pipe Specialist | Victor Juan |
| **FUJITA ENGENHARIA** | |
| Sector Coordinator | Paulo Ayrton Cavalcante Araújo |
| **BF CAPITAL** | |
| CFO | Renato José Silveira Lins Sucupira |


Cagece – Companhia de Água e Esgoto do Ceará
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Fone: (85) 3101.1719Fax: (85) 3101.1860

| | |
|---|---|
| CFO | Jacy do Prado Barbosa |
| CFO | Felipe Guidi |
| Financial Analyst | Otavio Fernandes |
| Financial Analyst | André Veloso |
| Financial Analyst | Gabriel Colturato |
| Financial Analyst | Bruno Taveira |
| **MANESCO ADVOGADOS** | |
| Lawyer | Floriano Peixoto de Azevedo Marques Neto |
| Lawyer | Wladimir Antônio Ribeiro |
| Lawyer | Marcos Augusto Perez |
| Lawyer | Raquel Lamboglia Guimarães |
| **TEIXEIRA ENGENHARIA** | |
| Civil or Sanitary Engineer | Nuno Pinto |
| Civil or Sanitary Engineer | Samuel Paim |
| Civil or Sanitary Engineer | Daniele Cezarete |
| Civil or Sanitary Engineer | Vitor Faria |
| Civil or Sanitary Engineer | Carlos Fernandes Jorge |
| Civil or Sanitary Engineer | Abílio Garcia Castro |
| Civil or Sanitary Engineer | Nuno Martins |
| Civil or Sanitary Engineer | Olivier Passos |
| Civil or Sanitary Engineer | Nuno Vaz |
| Civil or Sanitary Engineer | Mario Augusto |
| Civil or Sanitary Engineer | Célia Tenente |
| Civil or Sanitary Engineer | Nuno Abecassis |
| Architect | Pedro Vicente |
| Architect | Rui Nunes Santos |
| Architect | Maria Inês Nogueira |



**Cagece – Companhia de Água e Esgoto do Ceará**
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