Xènia Balagué Trepat

Cooling Tower Design

Final Master Project
Adviser: Dr. Francisco González Molina

Master's degree in Industrial Engineering

UNIVERSITAT ROVIRA I VIRGILI

Tarragona
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UNIVERSITAT ROVIRA I VIRGILI

Tarragona
2023

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Document 2: Report

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1 Objectives

The main objective of this project is the design of a cooling tower for one of the chemical plants within the Tarragona complex. This chemical plant will increase its load capacity due to the growing market demand and, for this purpose, will install new units. These new ones will consume a quantity of cooling water that requires a new installation.

To carry out the design of the new cooling tower, the client provides the following technical data:

- Water flow rate to be cooled: 2,500 m^3/h.
- Inlet water temperature: 32°C.
- Outlet water temperature: 26°C.

Once the tower has been designed and all its components have been characterized, the selection and justification of the required instrumentation is carried out.

Additionally, the new unit will include the capacity of the power loads.

As this project deals with a new unit, it includes a section detailing the chemical treatment required for water treatment. This treatment is needed for both the initial startup i.e., Legionella disinfection in accordance with the RD and system passivation, and for normal operational conditions. The aim is to ensure effective control of corrosion, scaling, and microbiological growth to maintain optimal functionality. Chemical treatment plays a critical role because the majority of industrial production processes require cooling water to operate efficiently and safely.

Furthermore, a programme for monitoring variables is included.

Finally, the budget will be presented for the project, dividing the costs between required investment and operational costs.

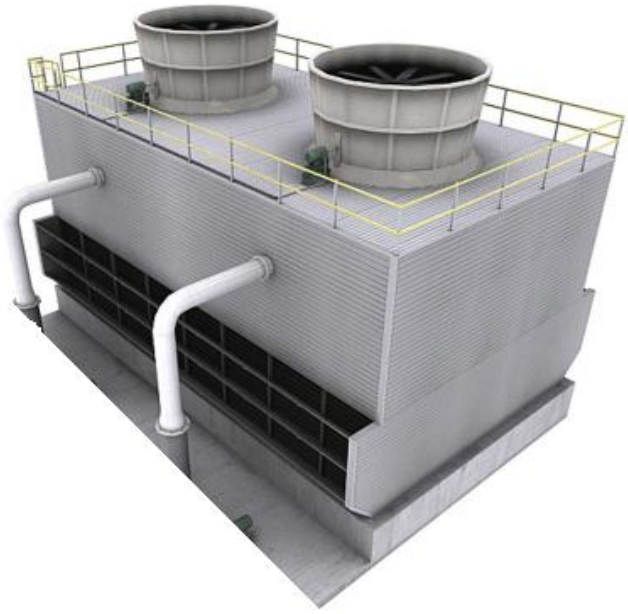

Figure 1.1. Cooling tower.

2 Scope

The aim of the project is to design an efficient and functional cooling tower for the cooling system of the new chemical plant expansion.

The scope of the project includes:

- Conducting an exhaustive study of the different types of cooling towers.
- Selecting a cooling system suitable for the cooling capacity and local climate factors.
- Defining and selecting tower components. Choosing materials resistant to corrosion and suitable for the industrial environment.
- Detailed design of the cooling tower. Performing design calculations for fundamental parameters and sizing the unit.
- Sizing and selecting the fans and pumps required by the system.
- Selecting the necessary instrumentation for system control and monitoring.
- Making partial load predictions for components with known power consumption.
- Preparing and executing the system startup, focusing on chemical treatment. Implementing flushing, disinfection, and passivation processes i.e., forming a protective layer on metal components to reduce corrosion.
- Carrying out a chemical treatment to prevent corrosion, scaling, and microbiological growth.
- Establishing a continuous system for monitoring water quality variables such as pH, conductivity, chlorine, etc.
- The budget required for the new unit will be detailed, dividing the costs into investment costs and operational costs.

This project has been defined with an exclusive focus on the design and operation of the cooling tower. Therefore, the following elements are excluded from the project scope:

- Design of the comprehensive electrical installation. The detailed design of the electrical installation is not included in the project. This encompasses the transformer station, service connection, protective enclosures, and cable distribution. The electrical installation should be covered in a separate project.
- Design of the system filters. The design of filters that might be necessary for cooling tower operation and component protection against particles and sediments is not considered in this project. This includes selecting, sizing, and detailed design of filters to be integrated into the system.

3 Introduction

3.1 Definition and importance

Cooling towers are mechanical systems used to exchange energy between a body of water and a stream of air. [1]

The fundamental principle of operation of these systems is based on evaporation: inside the equipment, a cloud of water droplets is produced either by spraying or by free fall, which comes into contact with a stream of air. The superficial evaporation of a small part of the water due to heat exchange with the air leads to the cooling of the rest of the water, which is collected at a lower temperature and returned to the cooling cycle.

Water cooling systems have been used for industrial purposes and/or air conditioning since the beginning of the last century. The principles and techniques have not substantially changed, as the basis of the system is very simple. However, there has been substantial evolution in recent years in terms of the quality of materials and the accessibility of installations.

Most industrial production processes require cooling water to operate efficiently and safely. Refineries, steel mills, petrochemical manufacturing plants, electric companies, etc., depend on equipment or processes that will not function properly or efficiently if the temperature is not correct. Water cooling systems control these temperatures by transferring heat from the hot fluids of the process to the cooling water that carries the heat. When this happens, the cooling water is heated and must be cooled before it can be used again or gradually replaced with a fresh supply of cooled water. Unfortunately, this "fresh" replacement water contains minerals, dirt, waste, bacteria, and other impurities. As the water continues to circulate through the system, other contaminants begin to accumulate. Soon, temperatures begin to rise, the efficiency of the cooling equipment is affected, and it can result in a complete plant shutdown.

3.2 Sanitary importance of Legionellosis

On the other hand, there is an important factor to consider regarding the maintenance of cooling towers. Some local administrations are restricting or making it difficult to install them due to their environmental impact. One of the most serious problems that these systems can cause is the spread of Legionella. [8] [9]

Legionellosis is an infectious disease caused by the Legionella bacteria in 90% of cases and can be fatal. Traditionally, two clinical forms of Legionella infection have been classified:

- Legionella pneumonia or "Legionnaires' disease." A more severe disease that causes pneumonia and very high fever.
- Pontiac fever. A milder disease that does not cause pneumonia.

Legionella is considered an environmental bacterium that can be found in any accumulation of surface water as part of its bacterial flora: lakes, rivers, ponds, thermal waters, etc. This bacterium has a bacillus shape that measures 0.3 to 0.9 μm wide and 2 to 20 μm long, being mobile with one or more flagella.

Figure 3.1. *Legionella* bacteria.

This bacterium is capable of surviving in a wide range of physicochemical conditions. It is important to understand the different behaviours of this bacteria based on temperature.

Table 3.1. Summary table of Legionella growth.

Temperature	**>20ºC**	**20-45 ºC**	**35-37 ºC**	**<50ºC**	**<70ºC**
State	Latent	Active multiplication	Optimal growth	Does not multiply	Non-viable

As seen in the table above, the bacterium is inactive at a temperature below 20ºC, meaning it does not multiply. Similarly, it can be inactivated at temperatures above 50ºC, and can even be eliminated at higher temperatures maintained for a minimum time. However, when working at temperatures between 20 and 50ºC, the bacterium is in the ideal environment for growth and multiplication, especially between 35 and 37ºC, which is its optimal growth temperature. This temperature is within the working temperature range of cooling towers. Additionally, if the tower is not properly maintained and stagnant water and nutrients for the bacteria, such as sludge, organic matter, corrosion material, and amoebas are favoured, it can promote a significant focus where the bacteria can grow.

If the above conditions are combined with installations that also include aerosol-producing elements, the bacteria can disperse and be transported through the air. These water droplets containing the bacteria can remain suspended in the air, be transported, and penetrate the respiratory system of people who are in the environment by inhalation.

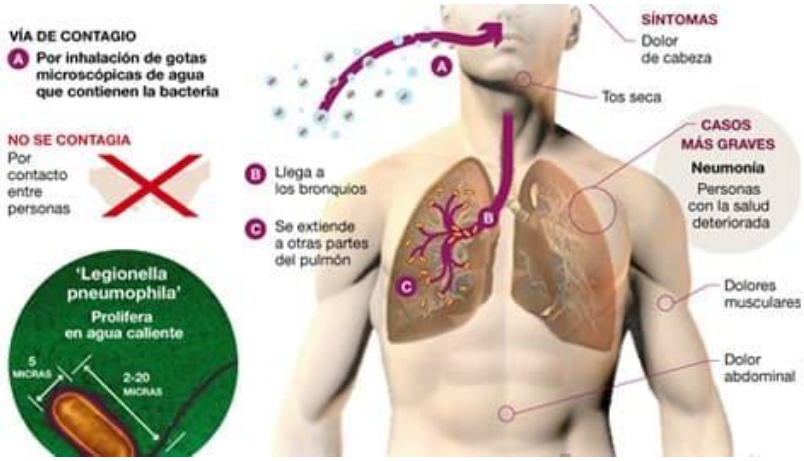

Figure 3.2. Transmission and symptoms of Legionella.

Figure 3.3. Legionella pulmonary infection.

Royal Decree 487/2022, of June 21, establishing health requirements for the prevention and control of legionellosis.

3.3 Types of Cooling Tower

Various types of cooling towers are designed and built, with different sizes available for each model. However, not all models are adequate for use in all heat load set ups. The following image contains a summary of the classifications. [2] [10] [11] [12] [13]

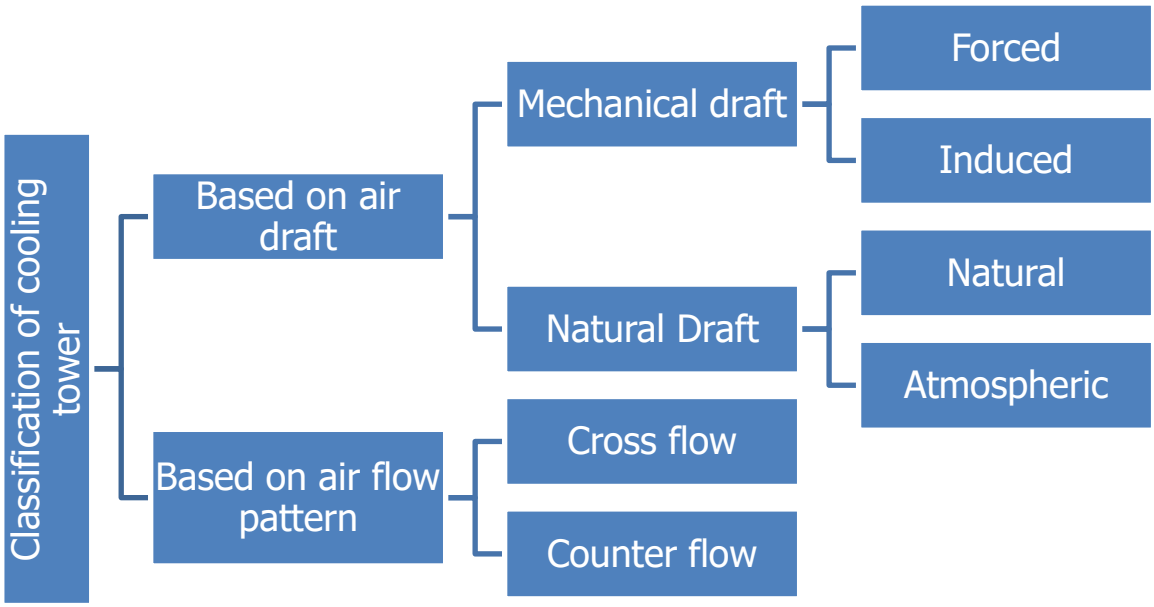

Figure 3.4. Classifications of cooling tower.

3.3.1 Classification based on air draft

A tower will be defined as mechanical or natural depending on the type of air flow received, i.e., with or without the use of ventilators.

3.3.1.1 Mechanical cooling towers

Towers powered by a mechanical force can control the air flow supply completely. These towers are compactly built and have a transversal (crossflow) section with the pump situated lower than towers receiving a natural air flow.

These towers use multiple or individual ventilators to produce a known volume of air flow through (up) the tower. Thus, thermal performance is more stable and less affected by psychrometric variables than that of atmospheric towers. The cycle or capacity of the ventilators can be modified to regulate the air flow and compensate for changing atmospheric conditions or varying load demands.

The outlet water temperature can be supervised very precisely in this type of tower, so it is possible to attain very low values of between 1º and 2ºC. However, in practice the temperature usually registers between 3º and 4ºC.

Towers with a mechanically induced draft are known as forced draft towers. A fan, placed in the path of the natural air flow entering the tower, either forces the air up and out, or in the case of induced draft sucks the air upwards through the tower and out.

- Forced draft. These towers offload/discharge the air slowly from the top of the tower and almost always use a counterflow mode. They are more efficient than those towers using an induced draft.
  The air that flows is cold air with a higher density than the air that flows through induced draft towers. This means that the mechanical equipment used in this process Will last longer than that used in induced draft towers as the fan is working with cold air that is not saturated and is therefore less corrosive than hot saturated outlet air. However, an important drawback involves the possibility that exiting air may drop to the low-pressure zone created by the fan at the inlet and then recirculate.
- Induced draft. Induced draft towers can be of counterflow or crossflow design. The advantage of these towers is that colder water comes into contact with drier air, resulting in maximum efficiency. In this type of tower, air can enter through one or more walls of the tower, which significantly reduces the height of the air inlet.
  On the other hand, the high velocity at which the air enters poses a risk of carrying dirt and foreign objects into the tower. The resistance of the ascending air against the falling water results in a significant loss of static pressure and, therefore, an increase in the ventilation power compared to crossflow towers.

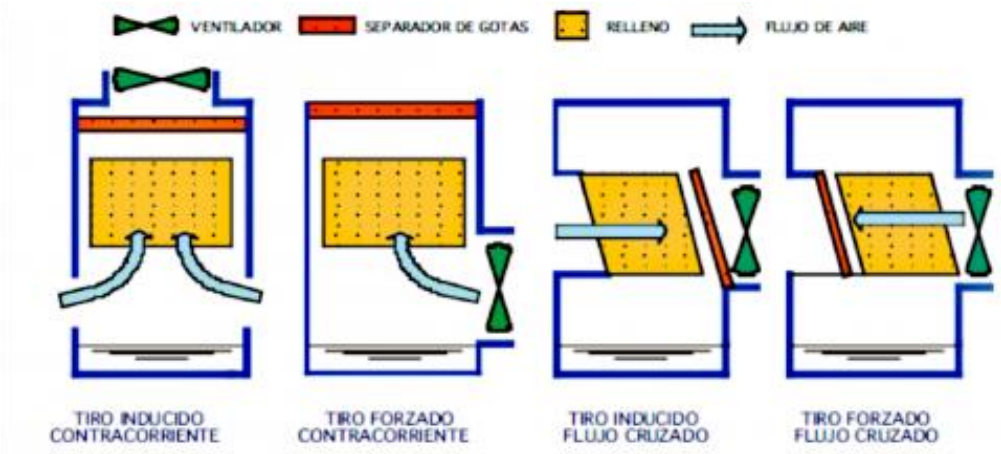

Figure 3.5. Mechanical cooling towers.

3.3.1.2 Atmospheric towers

In atmospheric towers the air flow is solely dependent on climatic and ambient conditions. They are classified into two groups: atmospheric towers or natural draft towers:

- Atmospheric towers. Atmospheric towers utilize air currents from the atmosphere. The air moves horizontally while the water falls vertically (crossflow). They are tall towers with a small cross-sectional area. They should be installed in clear areas where no obstacles can hinder the free circulation of air through the tower.
  They have a high initial cost due to their significant size, but the maintenance cost is reduced as there are no moving mechanical parts. A tower of this kind can be a very cost-effective solution for certain cooling needs if it can be ensured that it will frequently operate exposed to winds with speeds equal to or greater than 8 km/h.
  If the average wind speed is low, the fixed and pumping costs increase significantly compared to a mechanically induced draft tower, and they do not offset the savings in ventilation costs. The average temperature of the cold water obtained with an atmospheric tower will be lower than what could be achieved with a mechanically induced draft tower designed for the same operating conditions, as the actual wind speed tends to be lower than the design speed.
  The outlet water temperature will always depend on the speed and direction of the wind. With this type of tower, it is not possible to achieve a close approximation. Currently, atmospheric towers are no longer in use.
- Natural draft tower. A natural draft tower is one in which air is induced by a large chimney located above the fill. The density difference between the hot, moist air and the atmospheric air is the main reason for the air draft through the tower, along with the wind speed. For these reasons, natural draft towers need to be tall and have a large cross-sectional area to facilitate the upward movement of air.
  These towers are well-suited for cooling large water flows. Natural draft towers are not suitable when the dry air temperature is high because it must always be lower than the hot water temperature. It is not possible to achieve small approach values, and it is very difficult to control the water temperature precisely.
  In natural draft towers, compact fill materials cannot be used because the air flow resistance must be as low as possible. These towers are commonly used in thermal power plants but are rarely employed in industrial plants due to the significant initial investment required.

Figure 3.6. Natural draft cooling tower.

3.3.2 Classification based on air flow pattern

3.3.2.1 Counterflow

In counterflow towers, the air moves vertically upward through the tower, opposite to the downward flow of water. These towers require numerous intake and discharge stages and the use of high-pressure spray systems. Additionally, pressure losses are generally higher. This is the reason why some smaller counterflow towers have greater height, require higher pump head, and use more ventilation power than equivalent crossflow towers. However, in larger towers, the situation between the two types of towers is more balanced due to the use of low-pressure and gravity-related distribution systems, the availability of ample areas for air loading, and spaces for air treatment. Furthermore, due to their design, the exposure of water within these towers to sunlight is limited, which delays algae growth.

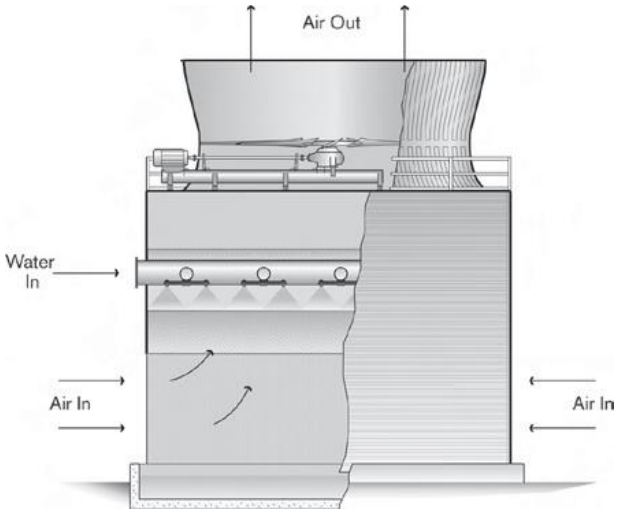

Figure 3.7. Counterflow mechanical induced cooling tower.

3.3.2.2 Crossflow

Crossflow towers have a fill configuration in which air flows horizontally, crossing the downward flow of water. The water to be cooled is supplied to the hot water inlet tanks located at the top of the fill areas and is gravity-distributed through measuring holes at the bottom of these tanks.

Maintaining these towers is less challenging than in the case of counterflow towers due to the ease of inspecting the different internal components of the tower. The main disadvantage of these towers is that they are not advisable for cases requiring a significant temperature difference and a small approach value, as this would result in a larger cross-sectional area and more ventilation power compared to a counterflow tower.

Crossflow towers can be divided into two groups:

- Double flow: In this type of tower, the fan induces air through two inlets and along two fills.
- Single flow: This type of tower has only one air inlet and one fill, with the other three sides of the tower covered. Single flow towers are mainly used in locations where air currents are available in only one direction.

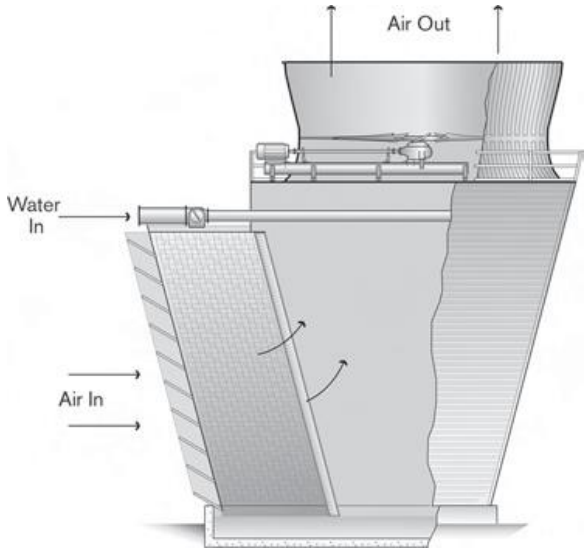

Figure 3.8. Single-flow mechanical induced crossflow cooling tower.

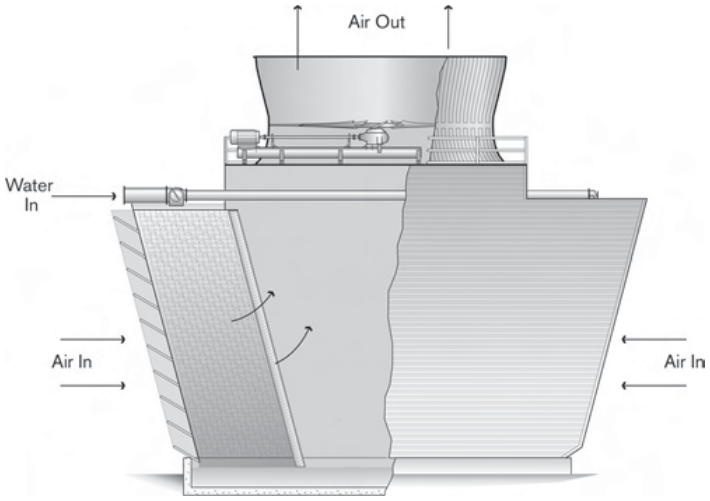

Figure 3.9. Double-flow mechanical induced crossflow cooling tower.

3.3.3 Other types of classification

3.3.3.1 Classification by manufacture

They can be classified as Factory Assembled or Field Erected. Factory-Assembled towers typically do not exceed a capacity of 2,250 m3/h, while Field-Erected towers can reach flow rates of 80,000 m3/h.

3.3.3.1.1 Factory-Assembled

Factory-Assembled towers undergo virtually complete assembly at their manufacturing point, after which they are shipped to the site in as few sections as transportation allows.

The small-sized tower shown in Figure 3.10 would be essentially intact when shipped. Larger multi-cell towers (Fig.3.11) are assembled as "cells" or "modules" in the factory and are shipped for the user to perform the final joining. Factory-assembled towers are also known as "packaged" or "unitary" towers.

Figure 3.10. Small-sized Factory-Assembled cooling tower.

Figure 3.11. Factory-Assembled multicellular cooling tower.

3.3.3.1.2 Field-Erected

Field-Erected cooling towers are used in a wide range of cooling applications, such as industrial processes, refineries, manufacturing, power plants, and more. The construction is carried out on the site of its final use. All large towers, and many smaller towers, are prefabricated, marked in pieces, and shipped to the site for final assembly. The labour and/or supervision for the final assembly is usually provided by the cooling tower manufacturer.

These towers are commonly constructed using treated wood, reinforced fiberglass, concrete, stainless steel, galvanized steel, or coated metals.

Figure 3.12. Field-Erected multicellular cooling tower.

3.3.3.2 Classification by shape

There are two different types of towers based on shape:

- Rectangular. Towers constructed in a cellular form, increasing linearly in length and the number of cells required to achieve a specific thermal performance.
- Round Mechanical Draft ("RMD"). Towers, as the name suggests, that have an essentially round layout, with fans grouped as closely as possible around the central point of the tower. Multifaceted towers, like the octagonal mechanical draft ("OMD") design shown in Figure 3.13, also fall under the general classification of "round" towers. Such towers can handle substantial heat loads with a considerably smaller site area impact than required by various rectangular towers. Additionally, they are significantly less affected by recirculation.

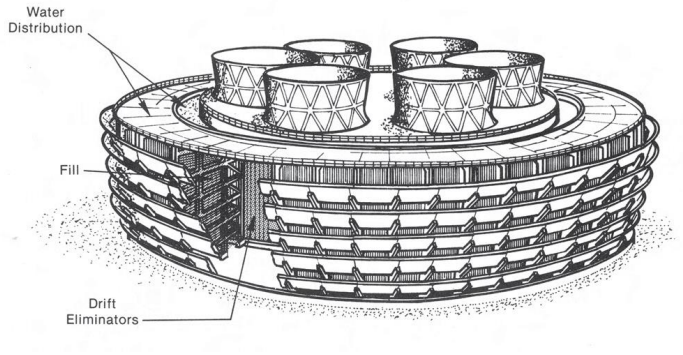

Figure 3.13. Octagonal configuration mechanical draft cooling tower.

4 Standards and references

4.1 Legal provisions and applied standards

[1] Royal Decree 487/2022, of June 21, establishing health requirements for the prevention and control of legionellosis.

[2] Royal Decree 552/2019, of September 27, approving the Safety Regulation for Refrigeration Installations and the complementary technical instructions.

4.2 Calculation programs

The calculation programs used for this project:

- AutoCAD: Used for creating the drawings.
- Howden: Used for fan design.
- Sicro: A program from the Polytechnic University of Valencia used for obtaining values from the psychrometric chart.
- Gantt Project: Used for project planning.

4.3 Quality management plan applied

Not applicable in this project.

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5 Definitions and abbreviations

In this section, the main parameters for this type of project have been defined, along with a brief description for each of them. The following table shows these parameters. [5]

Table 5.1. Definition of the main parameters.

Parameter	Definition
Approach	Difference between the cooled water temperature outlet and the inlet wet bulb temperature.
Blowdown	Condenser water purposely discharged from the system to control concentration of solids or other impurities in the water.
Drift	Unevaporated water droplets that are lost from the cooling tower.
Dry bulb temperature	Temperature of air measured with a standard thermometer that is not affected by moisture content.
Evaporation (loss)	Condenser water that undergoes a phase change from liquid to vapour and exits the tower as a part of an air-vapour mixture.
Height of Transfer Units (HTU)	Represents the height of an imaginary equilibrium stage in a cooling tower.
Make-up (water)	Water added to offset water loss through evaporation, drift, and blowdown.
Number of Transfer Units (NTU)	Dimensionless parameter used to quantify the heat transfer efficiency in a cooling tower.
Range	Temperature difference between the water that enters the cooling tower i.e., hot water from an industrial process, and the water that exits the tower after being cooled down by an evaporation process.
Wet bulb temperature	Lowest temperature that can be reached by evaporating water into the air at a constant pressure.

6 Cooling tower choice. Justification

The choice of the best cooling tower for the requirements of this project depends on the type of plant, quantity of water to be cooled and investment costs. Specific necessities for the cooling system have been considered.

For this project, the cooling tower will be installed in a chemical plant in Tarragona, Spain.

Figure 6.1. Cooling tower location.

The main variables to be taken into account for the tower design are shown in Table 6.1. Certain variables such as the flow to be cooled and the inlet and outlet water temperature have been defined by the client.

- Water flow to be cooled: 2,500 m3/h
- Inlet and outlet water temperature: 32-26ºC
- Wet bulb temperature
- Height (a.s.l.)
- Weather conditions on site: see Table 6.1.

Table 6.1. Weather conditions on site.

Variable	Units	Value
Average annual temperature	ºC	15.7
Maximum temperature	ºC	35.0
Minimum temperature	ºC	0
Average annual relative temperature	%	70.0
Maximum relative humidity	%	100.0
Minimum relative humidity	%	40.0
Dry bulb temperature	ºC	25.0

The following table shows a comparison between natural draft and mechanical draft cooling tower. [5] [10]

Table 6.2. Comparison of different types of cooling towers.

	Natural draft	Mechanical draft
Tower height	High	Low
Airflow	Low or natural airflow	Mechanical force establishes airflow
Fan	Not required	Requires a fan.
Noise	N/A	Higher noises levels
Heat transfer between water and air	Low	High
Operating cost	Low	High
Initial investment	High	Low
Capacity	Increasing capacity requires increasing tower height.	Increasing fan speed can increase capacity
Temperature control	Difficult water outlet temperature control. Difficult to achieve very small approach values.	Good water outlet temperature control and can achieve very small approach values.

After reviewing the previous table, the use of natural draft towers would not be considered due to their disadvantages. For the design of the tower according to the established requirements, precise temperature control and ensuring higher heat transfer between water and air are needed.

Another factor to be considered is that the classification of natural draft towers is not suitable for the type of installation intended for this project design. As mentioned before, atmospheric natural draft towers are currently outdated, and natural draft towers are commonly used in thermal or nuclear power plants.

Therefore, the design will focus on a mechanical draft cooling tower. These type of cooling towers can be either forced draft or induced draft. A comparative table between both of them is presented below.

Table 6.3. Comparative table of mechanical draft cooling tower type.

	Forced draft	**Induced draft**
Cooling Capacity	Good cooling capacity	Greater capacity due to efficient removal of hot and humid air from the bottom
Size	Typically, smaller dimensions	Larger dimensions
Fan	Axial or centrifugal fan at the air inlet	Axial fan at the top of the tower
Fan Location Issues	Potential freezing issues when located at the air inlet	None
Motor Power	High power	Low power
Airflow resistance	Greater due to lower fan placement	Lesser due to upper fan placement
Discharge velocity	Low. Saturated air tends to recirculate, reducing cooling capacity	High. Prevents recirculation
Maintenance access	Greater difficulty in access	Better access to tower elements
Efficiency	Normal	More efficient than forced draft types

An induced draft cooling tower has been selected as it offers higher efficiency in terms of energy consumption and performance compared to forced draft towers. Additionally, they have lower energy consumption for fan operation.

Once the tower design has been decided, the airflow-water configuration must also be considered. Their characteristics are shown in Table 6.4.

Table 6.4. Comparation based on air-water flow.

	Crossflow	**Counterflow**
Heat transfer efficiency	Low efficiency due to cold air contacting hot water.	Higher efficiency with cold air contacting cold water
Fan power	Requires low power.	High power.
Air velocity	High. Risk of entraining dirt and foreign bodies into the tower.	Low.
Saturated air recirculation	Highly likely.	Less likely.
Fouling	Highly likely.	Less likely.
Initial cost	Higher initial cost due to design complexity.	Lower initial cost.

As observed in the above table, after evaluating the various advantages and disadvantages for the different cooling tower types, for a chemical industry in Tarragona, an induced draft counterflow cooling tower will be used. Despite the low quantity and velocity of air, this choice ensures greater efficiency under different weather conditions, a lower likelihood of fouling, and avoids the risk of entraining dirt and foreign bodies into the tower, which directly impacts system efficiency.

7 Design requirements

7.1 Design data

The data for the tower design are presented in Table 7.1.

Table 7.1. Design data.

Variable	Value
Water flow rate to be cooled (m3/h)	2,500
Dry bulb temperature (ºC)	25
Relative humidity (%)	70
Hot water temperature (ºC)	32
Cold water temperature (ºC)	26
Altitude (m)	0
Atmospheric pressure (atm)	1

7.2 Process description

The cooling tower for this project is an induced draft counterflow type. This type of tower is the most commonly used in the chemical industries in Tarragona. The following table shows the description and the operation of a cooling tower. [2] [13]

Table 7.2. Cooling tower operation description.

Step	Description
1	**Reception of hot water.** The hot water that needs to be cooled enters the tower at a temperature of 32 ºC. This water, also known as process water, comes from condensers, heat exchangers, reactor jackets, furnaces, etc. The hot water flows into the collector.
2	**Distribution of hot water.** Once the water flows into the collector, it is uniformly distributed over the surface of the fill.
3	**Contact with air.** Fresh air enters from the bottom of the tower and rises through the fill in the opposite direction to the water flow.
4	**Heat transfer.** As the air moves through the fill, it absorbs heat from the hot water, so that part of the water cools as it evaporates.
5	**Evaporation and cooling.** The hot air is expelled from the top of the tower into the atmosphere, aided by fans placed at the top of the tower.
6	**Capture of water droplets.** To ensure minimal entrainment losses, drift eliminators will be installed to catch the water droplets carried by the air and direct them downwards.
7	**Collection and recirculation.** The cooled water that does not evaporate is collected in the tower basin and returned to the cooling system. This water exits the tower at a temperature of 26ºC.

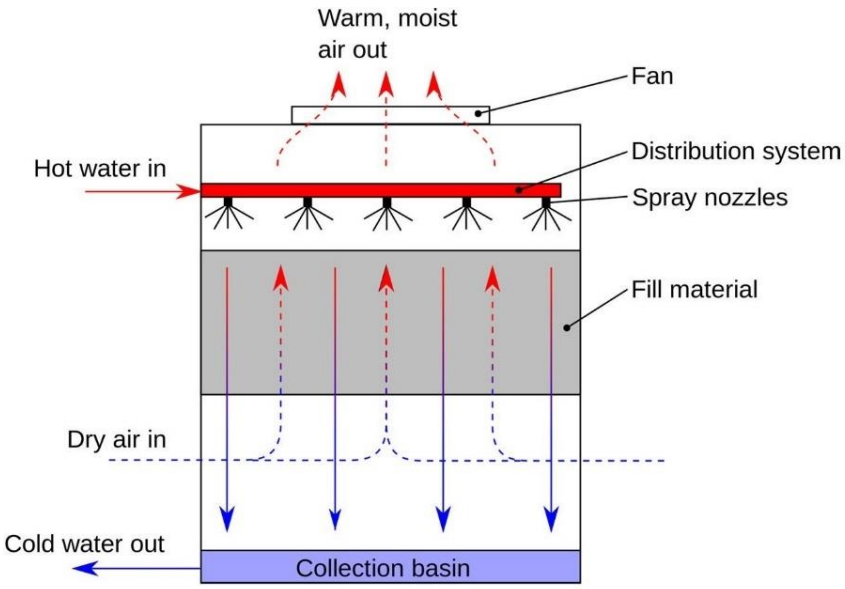


Figure 7.1. Cooling tower operation.

7.3 Components of a cooling tower

The components that will constitute the cooling tower have been defined. [2] [5]

7.3.1 Structural

7.3.1.1 Framework

The framework of a cooling tower is the main element as it serves as the support for all internal components and provides structural integrity. It is designed to house the fill, water distribution system, fan, and other key components.

The framework of a cooling tower can be constructed using different materials, which are chosen based on factors such as durability, chemical resistance, cost, and availability. Some commonly used materials are:

1. Wood: Wood was the most commonly used material in the past, but it is not a common practice nowadays due to its limitations in terms of structural strength, durability, and maintenance. However, in certain cases and under specific conditions, constructing a tower using properly treated wood can be considered.
2. Galvanized Steel: Galvanized steel is widely used in cooling tower construction due to its resistance to corrosion and durability. However, it can degrade easily and suffer significant load losses due to fouling and corrosion. To address this, the steel is coated with a layer of zinc to protect it from oxidation and corrosion caused by contact with water and chemicals.
3. Reinforced Concrete: Reinforced concrete is used in the construction of large cooling towers, such as natural draft towers. It involves reinforcement columns made from a combination of concrete and steel that provides structural strength and durability. It does not require specific chemical treatment for maintenance and offers high resistance.
4. Fiberglass Reinforced Plastic (FRP): FRP is a composite material that combines polyester resins with fiberglass. It is resistant to corrosion and has a good strength-to-weight ratio, making it suitable for cooling tower construction as it can be moulded into various shapes and sizes.

Among the materials mentioned, both reinforced concrete and fiberglass reinforced plastic are the most suitable choices. However, reinforced concrete is typically used in larger cooling towers like natural draft towers. Therefore, for a mechanically induced draft cooling tower, an FRP structure would be more advantageous:

- Good corrosion resistance and compatibility with the chemicals present in the water circulation system.
- Durability. It can withstand extreme weather conditions, including varying temperatures and humidity.
- Lightweight material. FRP is lightweight, making installation easier and reducing stress on the supporting structure.

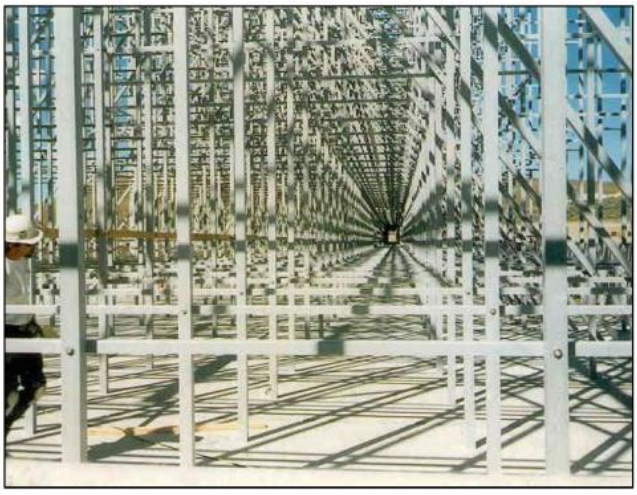


Figure 7.2. FRP framework of a cooling tower.

7.3.1.2 Casing

The casing of a cooling tower refers to the structure that surrounds and protects the tower. The purpose of the casing is to maintain a controlled environment and safeguard the internal components of the tower from external factors such as weather, dust, or pollution.

The casing can have various designs and materials, but it typically consists of panels or walls that encircle the tower, creating an enclosure. The material of the casing should be as opaque as possible, thus preventing the entry of light so as to inhibit the proliferation of algae, fungi, and bacteria.

Figure 7.3. FRP casing.

7.3.1.3 Cells

Cells, also known as flow splitter screens, are used to divide zones within the equipment. They serve as windbreaks and help prevent turbulence in areas where air currents coincide. Cells in a cooling tower can serve several purposes:

1. Airflow Distribution: Cells can help direct and evenly distribute airflow through the fill, allowing for efficient heat transfer.
2. Compartmentalization: Cells divide the internal space of the tower, enabling better management and control of water and air flow in different areas of the tower.
3. Maintenance and Access: Cells can facilitate access and maintenance of the internal components of the tower.

7.3.1.4 Fan cylinder

Fan cylinders are used to provide the fan with a housing and enhance its efficiency of operation. Furthermore, they serve as protection for the mechanical equipment. They prevent recirculation issues by facilitating the discharge of humid air, reduce the energy consumption needed to propel a specific volume of air, and eliminate turbulence that causes the constriction of flow lines as they pass through the fill.

Figure 7.4. Cooling tower fan cylinder.

7.3.2 Hydraulic

7.3.2.1 Water distribution system

The water distribution system in a cooling tower is responsible for supplying and ensuring efficient water distribution throughout the fill to facilitate heat transfer and maximize evaporative cooling.

The water distribution system in a tower can operate either by pressure or gravity. The gravity-based system is typically used in crossflow towers, while the pressure-based system is employed in counterflow towers.

In the gravity-based water distribution system, water flows by gravity from a basin or a supply source located at a higher elevation than the tower. The water is directed through pipes and nozzles to the tower fill, utilizing gravity to ensure even distribution. The advantages of this system are that water pumps are not required to generate pressure, and this reduces electricity consumption and provides greater simplicity in installation and maintenance.

However, it has limitations concerning flow regulation in each cell and the location of the supply source.

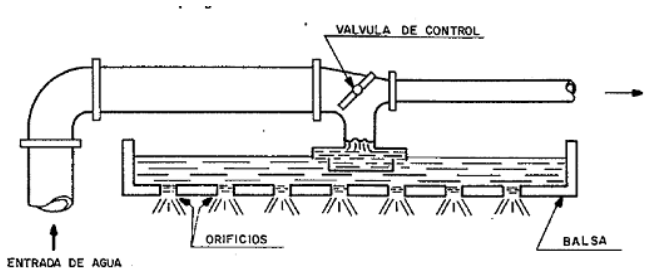


Figure 7.5. Gravity-based water distribution system.

In the pressure-based water system, water is pumped from a supply source such as a basin or an external source. The pumps generate the necessary pressure to distribute the water through pipes and nozzles to the tower fill. The water pressure ensures even distribution over the fill, facilitating the cooling process and thus providing greater control and adjustment of the flow and water distribution in the tower. However, having a pumping system requires higher energy consumption and, consequently, greater complexity in installation and maintenance.

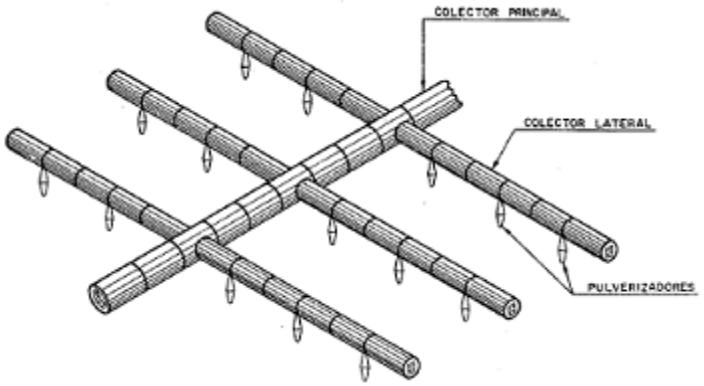


Figure 7.6. Pressure-based water distribution system.

The new cooling tower will feature a pressure-based water distribution system as the flow is counterflow.

7.3.2.2 Inlet water collector

The inlet water collector in a cooling tower is an essential part of the cooling system. It is the pipe through which the water to be cooled enters. Its role is to ensure that the water enters the tower uniformly and efficiently.

7.3.2.3 Nozzles

The nozzles or sprayers in a cooling tower are components used to spray water over the tower fill. Their main function is to evenly distribute water over the cooling area, promoting efficient heat transfer and enhancing tower performance. They atomize the water into small droplets, thereby increasing the surface area in contact with the air and facilitating evaporation.

Figure 7.7. Nozzles.

There are different types of nozzles, among which the following stand out:

- Low-pressure nozzle sprayers. These have nozzles that atomize water into a defined spray pattern. They can be located on the top of the pipe (up-spray) or on the bottom (down-spray). They can be single or multiple nozzles, and their design allows for adjusting the angle and spray flow rate according to the system needs.

Figure 7.8. Nozzle on the bottom of the pipe.

- Splash plate sprayers. These have a plate-shaped design with small perforations. Water is sprayed through the perforations, creating a wide and uniform spray pattern. They are more commonly used in gravity distribution systems.

For a pressure distribution system, low-pressure nozzle sprayers have been used and located on the bottom of the pipe (down-spray).

7.3.2.4 Drift eliminators

The drift eliminator, also known as a droplet separator, is an important component in a cooling tower. Its main function is to capture water droplets carried by the airflow inside the tower and prevent them from escaping. This helps minimize water loss and improve the efficiency of the cooling process.

The drift eliminator is typically located at the top of the tower, just below the air outlet. It is designed with a configuration that allows air to pass through freely but captures water droplets carried by the upward air stream.

These devices also contribute to the homogenization of the airflow at the outlet of the fill, as the separators exert a pressure that acts as a buffer between the fill and the fan. Typically, the blades are made of Polyvinyl Chloride (PVC) and the supports are made of Polypropylene (PP).

Figure 7.9. Drift eliminator.

7.3.2.5 Cold water basin

The cold water basin is an important component in the water system of a cooling tower. It is a reservoir of water located at the bottom of the tower, where cooled water is collected before being recirculated back into the system.

The primary function of the basin is to store the cooled water that exits the tower fill. As water is distributed over the fill and comes into contact with counterflow air, some of it evaporates, cooling the remaining water. This cooled water is collected in the basin for later reuse in the cooling process.

Constructing the basin of an induced-draft cooling tower involves using materials that are durable, corrosion-resistant, and capable of holding large volumes of water.

The basin of a cooling tower must have the following characteristics:

- Accessibility for maintenance and cleaning tasks.
- Equipped with drains and overflow outlets, as well as connections for the purging system and water supply.
- Have a bypass system that can divert water when necessary, such as during startup.

7.3.3 Thermal

7.3.3.1 Fill (Heat transfer)

Fill, in cooling towers, is the area where thermal exchange takes place.

The fill of a cooling tower is a key component located within the tower and aims to increase the contact surface between hot water and air to promote efficient heat transfer. The fill is used to maximize evaporative cooling. The main characteristics of fill in a cooling tower are:

- Extended surface: The fill is designed with a large surface area, which helps maximize heat transfer between water and air. The extended surface allows for greater evaporation and more efficient water cooling.
- Support structure: The fill has a structure in the form of sheets, grids, or blocks, designed to maintain a stable and sturdy configuration.
- Uniform water flow: The fill is designed to evenly distribute water over its surface. This is achieved through channels and deflectors that guide water flow and prevent the formation of preferential channels, ensuring even distribution of water across the entire fill surface.

- High cooling efficiency: The design of the fill promotes efficient mixing of air and water, favouring heat transfer. By increasing the contact surface and allowing uniform water distribution, the fill optimizes the cooling efficiency of the tower.
- Corrosion resistance and durability: The fill is made from corrosion-resistant and durable materials capable of withstanding environmental conditions and exposure to water and air over extended periods.
- Ease of maintenance: The design of the fill allows for proper access for maintenance and cleaning. This is important to ensure optimal performance of the cooling tower and prevent the accumulation of sediment or deposits in the fill.

There are different types of fill used in induced-draft cooling towers, with the most common ones being:

- Film or laminar fill: This is one of the most common types used in cooling towers. They are often made of PVC. It is also known as crossflow fill or extended surface fill. This type of fill is designed to promote the formation of a thin film of water on its surface, thereby increasing the contact surface between water and air for efficient heat transfer. The following table shows the different advantages and disadvantages it presents.

Table 7.3. Advantages and disadvantages of film-type fill.

Advantages	Disadvantages
High cooling efficiency. Film fill allows for an extensive contact surface between water and air, promoting efficient heat transfer and greater cooling capacity.	**Higher initial cost.** Film fill tends to be more expensive compared to other types of fill due to its design and manufacture.
Lower energy consumption. Due to higher cooling efficiency, film fill may require less energy to achieve the same cooling capacity compared to other types of fill.	
Lower sensitivity to water quality. Film fill is less susceptible to clogging issues caused by suspended solids in water, making it suitable for waters with certain levels of contaminants or sediments.	

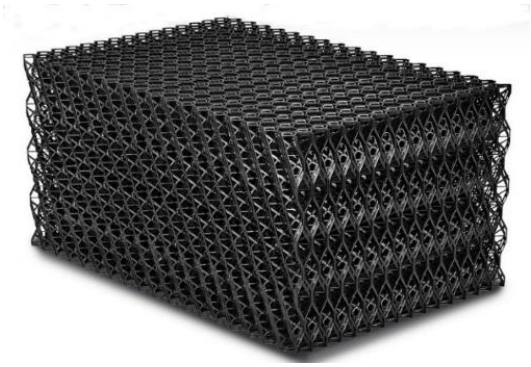


Figure 7.10. Film- type fill.

- Splash or grid-type fill. This is another common type of fill used in cooling towers. It is also known as parallel flow fill or direct contact fill. Unlike film fill, splash or grid-type fill does not form a water film but promotes direct contact between water and air to achieve heat transfer. Table 7.4 describes the advantages and disadvantages.

Table 7.4. Advantages and disadvantages of splash-type fill.

Advantages	Disadvantages
Resistance to clogging. The open design of splash fill allows for the passage of water and air, reducing the likelihood of clogging caused by sediments or dirt.	**Lower cooling efficiency.** Splash fill does not offer as extensive a contact surface as film fill, which can result in lower cooling efficiency in certain cases.
Higher tolerance to load variations and water conditions. Splash fill can handle better changes in thermal load and water conditions, making it more flexible in different operating conditions.	**Higher energy consumption.** Due to lower cooling efficiency, higher energy consumption may be required to achieve the same cooling capacity as with film fill.

Figure 7.11. Splash-type fill.

To ensure the cooling tower is efficient and high-performing, film-type fill has been selected due to the following considerations:

- Optimization of heat transfer. Film-type fill offers a more extensive contact surface, thus promoting efficient heat transfer and greater cooling capacity.
- Energy efficiency. The low pressure drop of film-type fill directly contributes to the energy efficiency of the system. The reduced resistance of the airflow optimizes the energy required to move air through the tower. This results in lower energy consumption and more sustainable operation throughout the tower lifespan.

7.3.4 Mechanical

7.3.4.1 Recirculation pumps

Recirculation pumps play a crucial role in supplying water to the system and continuously recirculating the cooled water. These pumps are responsible for maintaining a steady flow of water through the distribution system and the tower fill.

These pumps are selected based on the required water flow for the cooling system and the specific tower characteristics. The power and capacity of the pumps will depend on factors such as the tower size, the required water flow rate, and pumping power.

Centrifugal pumps with one or multiple stages have been used.

7.3.4.2 Fan

The fan is one of the most important components of a cooling tower. It generates an airflow that draws out the hot and humid air from the tower, facilitating heat transfer.

It is located at the top of the tower, and its main function is to create a vacuum effect by extracting the hot and humid air from the interior. As the hot air rises through the tower fill, the fan creates suction that helps expel the hot air to the outside.

The design of the fan allows for efficient air extraction. Generally, it consists of an electric motor connected to a shaft that drives the fan blades. The blades are designed to generate an upward airflow, creating a pressure difference that promotes the exit of the hot air.

The size and capacity of the fan are determined based on the airflow required for the cooling system, the tower dimensions, and specific performance requirements.

Figure 7.12. Cooling tower fan.

7.3.4.3 Motor

It is the power source of the fan, and both its supply, dimensions, protection, and sealing must be the correct ones to ensure its lifespan.

Therefore, the selection of a motor should be based on the environmental conditions it will be exposed to and the required power. Considering that the minimum nominal power of the motor must be at least 10% higher than the absorbed power.

7.3.4.4 Transmission

The transmission is composed of a gear box and a shaft responsible for transmitting the movement from the motor to the reduction shaft. The characteristics of rigidity and torsion, as well as the mechanical resistance to the working environment, are essential to ensure a long lifespan of this component.

7.3.4.5 Reducer

This is the component that supports the fan, so the mechanical equipment must prepare it to withstand its axial and radial loads. The reduction ratio must appropriately avoid exceeding the maximum tip speed of the fan blade, which could otherwise lead to its breakage. Neither must it lower the speed of design which what reduce the airflow circulating through the tower.

Reducers, like the entire mechanical assembly, must exhibit high chemical and mechanical resistance.

8 Cooling tower design

8.1 Fundamental parameters of the cooling tower

The fundamentals parameters for the design of a cooling tower are represented in Figure 8.1. [14]

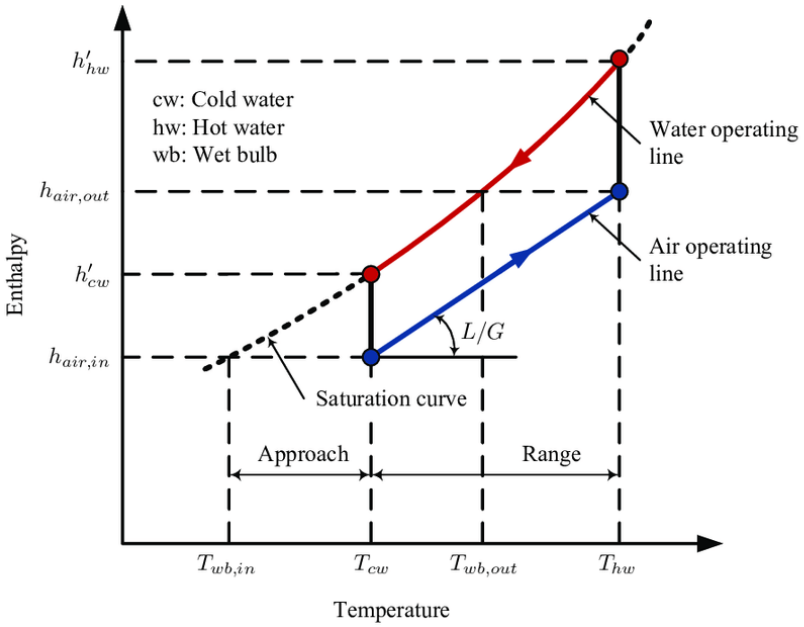


Figure 8.1. Enthalpy vs. Temperature diagram.

The graphic above represents the operational diagram of a cooling tower. The temperature and enthalpy values have been extracted from the psychrometric chart subject to the conditions of pressure and altitude in the system.

In Annex 2.1, the determination of various parameters from the psychrometric chart can be observed. The following table presents the obtained results.

Table 8.1. Fundamental parameters extracted from the psychrometric chart.

Parameter	Symbol	Value
Inlet dry bulb temperature (ºC)	$Td_{,in}$	25.0
Inlet wet bulb temperature (ºC)	$Twb_{,in}$	21.0
Outlet dry and wet bulb temperature (ºC)	$Td_{,out} = Twb_{,out}$	30.0
Approach (ºC)	a	5.00
Range or temperature difference (ºC)	ΔT	6.00
Inlet humidity ratio (g/kg dry air)	W_{in}	13.9
Outlet humidity ratio (g/kg dry air)	W_{out}	27.2
Dew point temperature (ºC)	Tr	19.1
Inlet enthalpy (kJ/kg dry air)	h_{in}	60.6
Outlet enthalpy (kJ/kg dry air)	h_{out}	99.7
Inlet specific volume (m3/kg dry air)	v_{in}	0.864
Outlet specific volume (m3/kg dry air)	v_{out}	0.896
Inlet wet air density (kg/m3)	$\rho_{da_{in}}$	1.174
Outlet wet air density (kg/m3)	$\rho_{da_{out}}$	1.146

8.2 Water flow balance

After obtaining the data from the psychrometric chart, the calculation of the L/G ratio and the number of transfer units have been carried out. The calculation procedure can be found in the annexes. [3] [4] [6] [7] [15] [16] [17] [18] [19]

Once the variables are known, the water flow balance of the system can be performed. Figure 8.2 represents the water flow balance of the cooling tower, and Table 8.2 provides a summary of the calculated parameters (detailed calculations can be found in the Annex 2.2).

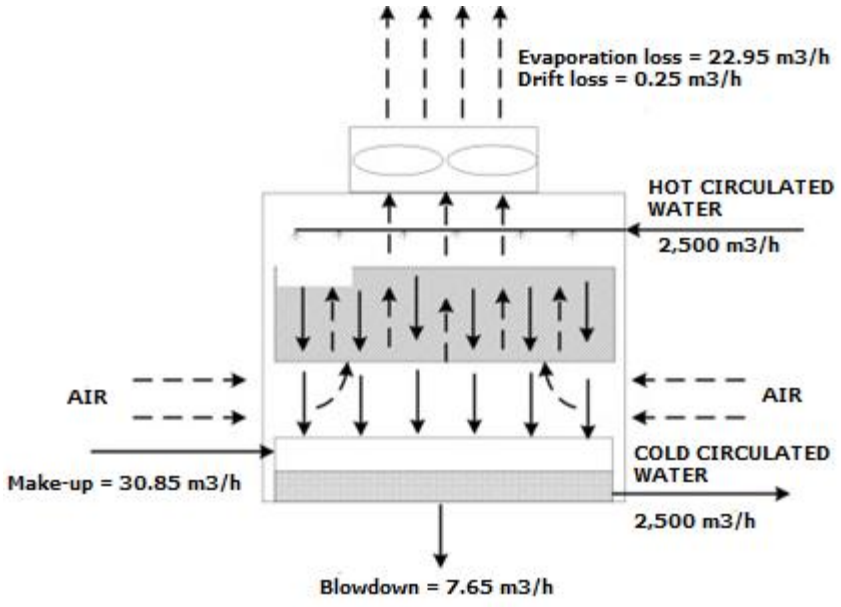


Figure 8.2. Cooling tower water flow balance.

Table 8.2. Summary table of calculated fundamental parameters.

Parameter	Symbol	Value
Recirculating Flow (m3/h)	L	2,500
Evaporation loss (m3/h)	E	22.95
Blowdown (m3/h)	B	7.65
Drift loss (m3/h)	D	0.25
Make-up (m3/h)	M	30.85
Relation L/G	L/G	1.559
Number of unit transfer	NTU	2.814
Air Flow (m3/s)	G	384.7
Number of cycles	C	4.00

8.3 Sizing of the cooling tower

In this section, detailed sizing of the cooling tower and its components has been carried out. The calculation procedures are presented in the annexes. [2] [5] [17] [20] [21] [22]

8.3.1 Cooling tower area

The cooling tower area is 200 m^2. It will consist of 2 cells, each measuring 10 meters in length and 10 meters in width, resulting in an area of 100 m^2 per cell. The following figure shows the dimensions of the cooling tower.

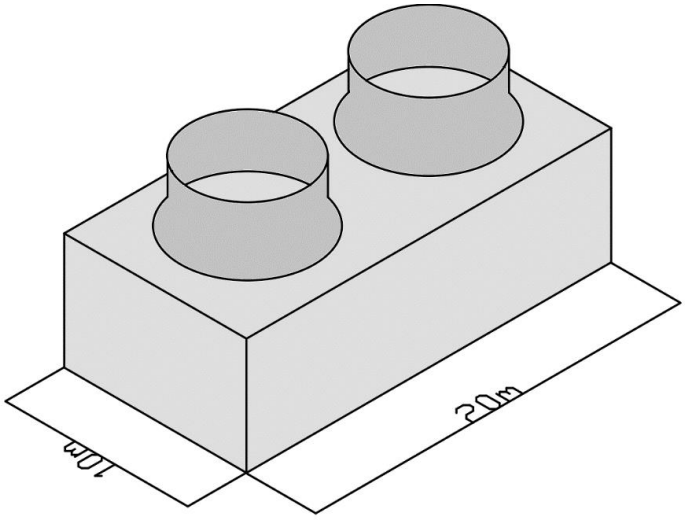


Figure 8.3 Cooling tower dimensions.

8.3.2 Air inlet height

Initially, to determine the total height of the cooling tower, the inlet air height has been calculated.

The inlet air height depends on the dry air volumetric flow rate, the incoming air velocity inside the tower, the length of the cells, and the number of cells.

The inlet air height is 3.8 meters.

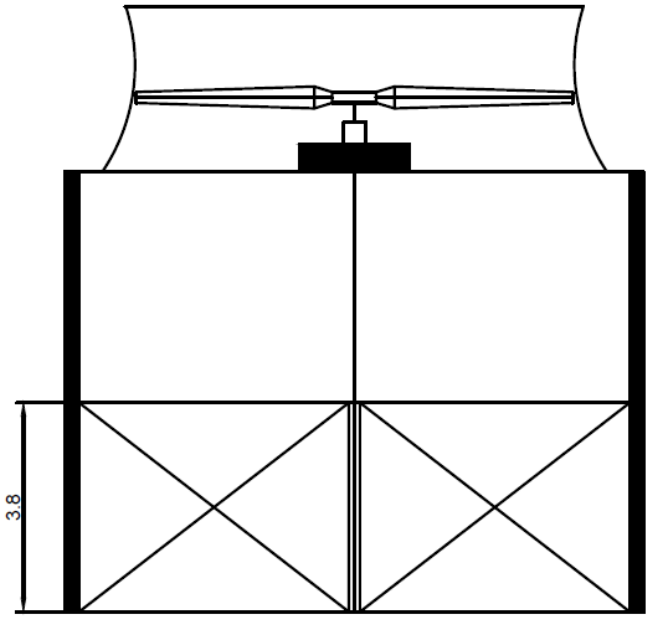


Figure 8.4. Inlet air height.

8.3.3 Fill (Heat transfer)

Above the inlet air height is the fill. A laminar fill type has been chosen.

According to the supplier's specifications for laminar fill, they are sold in packages of 0.6 meters each. Therefore, 4 packages of PVC, 0.6 meters in height have been selected.

The total fill volume used in the tower will be 240 m^3 per cell.

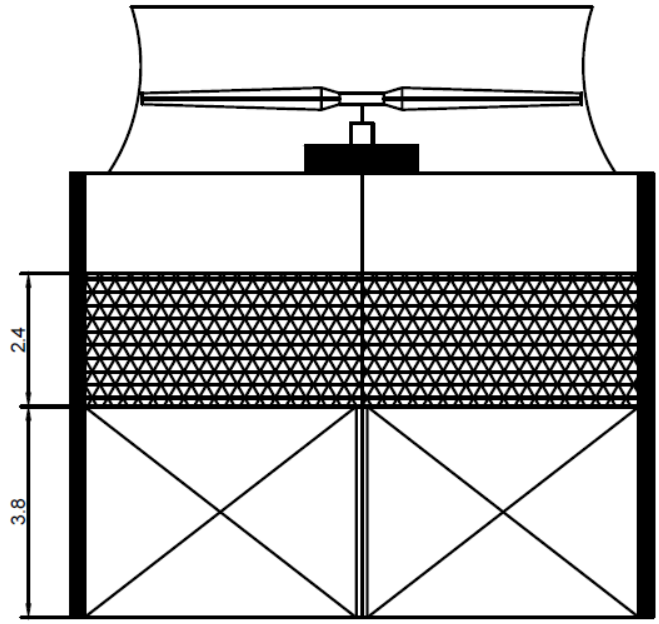


Figure 8.5. Fill height.

8.3.4 Water distribution system

The nozzles are placed above the fill. As defined in section 7.3, low-pressure nozzles have been considered.

The NS5 distributors from Marley's catalogue have been designated as they are suitable for counterflow cooling towers. This nozzle has a height of 0.2 meters, and the spacing between nozzles should be between 0.5 meters.

Figure 8.6. NS5 counterflow nozzle.

There is a separation distance in depth between the nozzles and the fill for proper dispersion and homogenization of water distribution. This area is called the spray zone or spray area. The recommended separation distance by the supplier is 0.4 meters.

The nozzles will be connected to the distribution system. These pipes have a diameter of 0.2 meters.

The distribution system collects water from the collector. The selected collector has a diameter of 0.5 meters.

The following figure illustrates the distribution system with its main components.

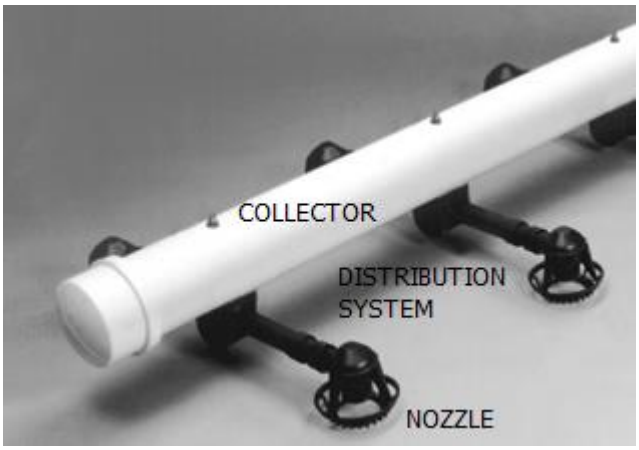


Figure 8.7. Counterflow Distribution Assembly.

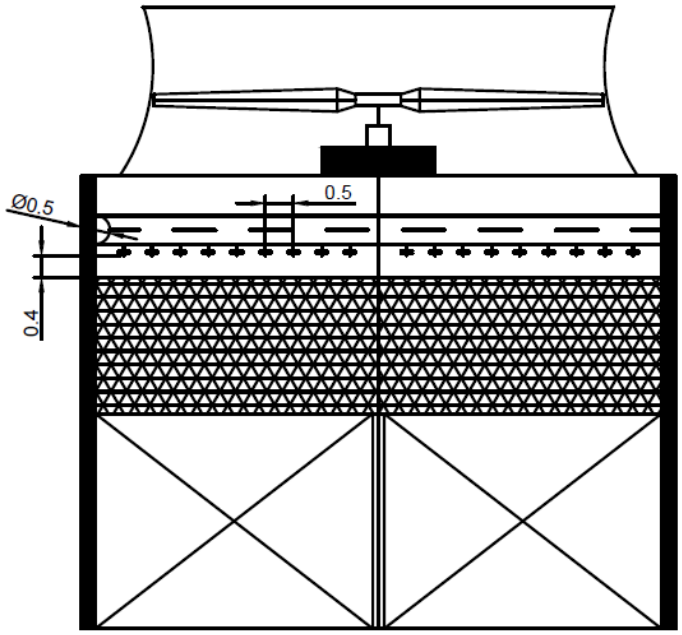


Figure 8.8. Water distribution system and water collector dimensions.

8.3.5 Drift eliminator

Above the distribution system are the drift eliminators. A drift eliminator has been selected that guarantees drag losses of less than 0.01% in the recirculation flow. The height of the separators is 0.2 meters. They will be located across the entire surface of the tower.

The area they will occupy is 40 m^2.

A distance of 0.5 meters is left above the separators for the placement of the mechanical group.

Therefore, the total height of the cooling tower, without considering the height of the fan cylinder, will be 8 meters.

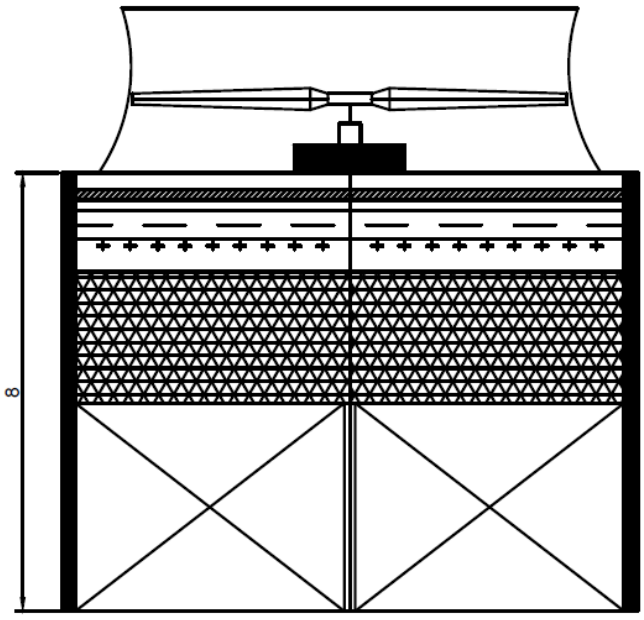


Figure 8.9. Total height of the cooling tower.

8.3.6 Cold water basin

To size the basin of the tower, the number of cells must be considered, and an additional 1 meter should be considered for both sides of the larger dimension. A height of 1.5 meters has been considered. The volume of the basin will be 360 m^3 and it will be constructed of concrete.

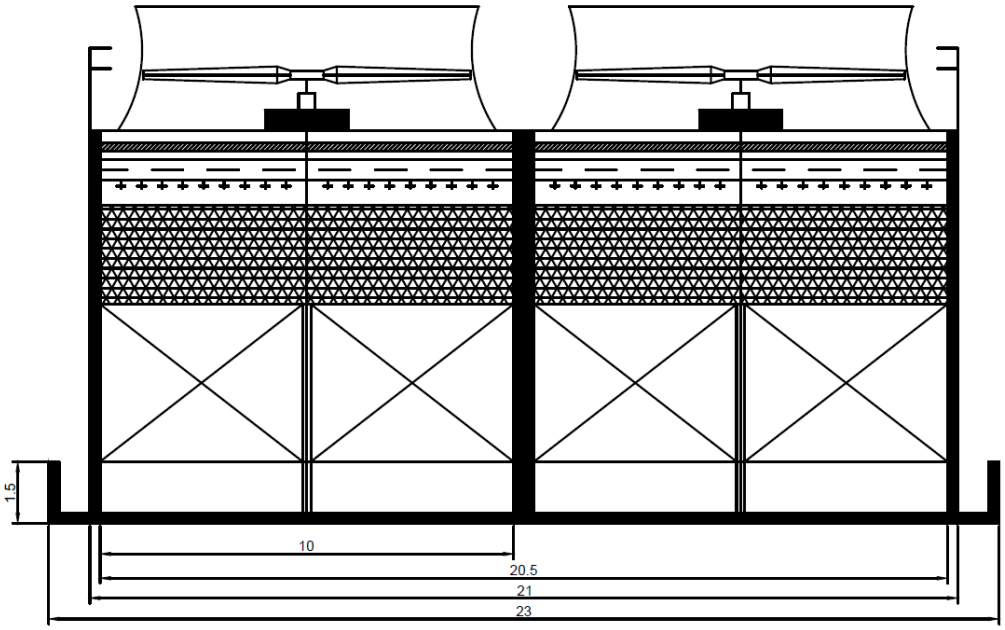


Figure 8.10. Cold water basin.

8.3.7 Framework

The framework of the cooling tower will be in Fiberglass Reinforced Plastic (FRP) since it is a corrosion-resistant material with a favourable strength-to-weight ratio. The beams supporting the structure will be positioned every 2.0 meters. An H-shaped FRP profile has been chosen for the entire structure, and for the corners, an angular profile will be used.

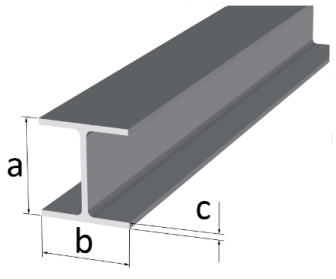


Figure 8.11. H-shaped FRP profile.

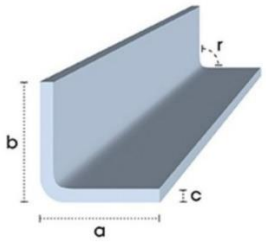


Figure 8.12. Angular FRP profile.

8.3.8 Casing

An FRP casing has been chosen and will be installed considering the height of the air inlet. The same casing will be used to cover the top of the tower. The approximate surface area of the enclosure needed is 460 m^2.

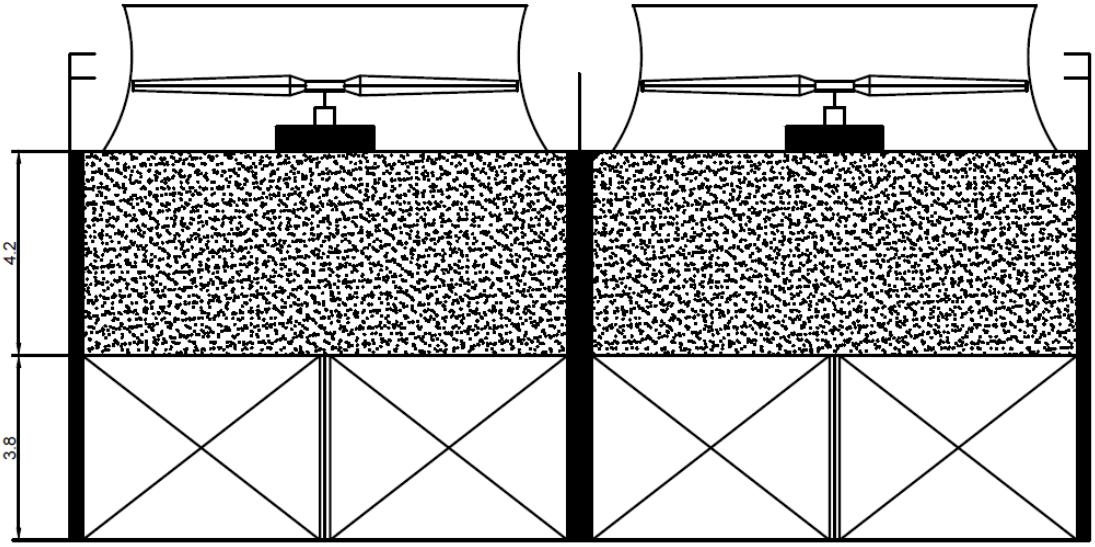


Figure 8.13. FRP casing.

8.3.9 Fan

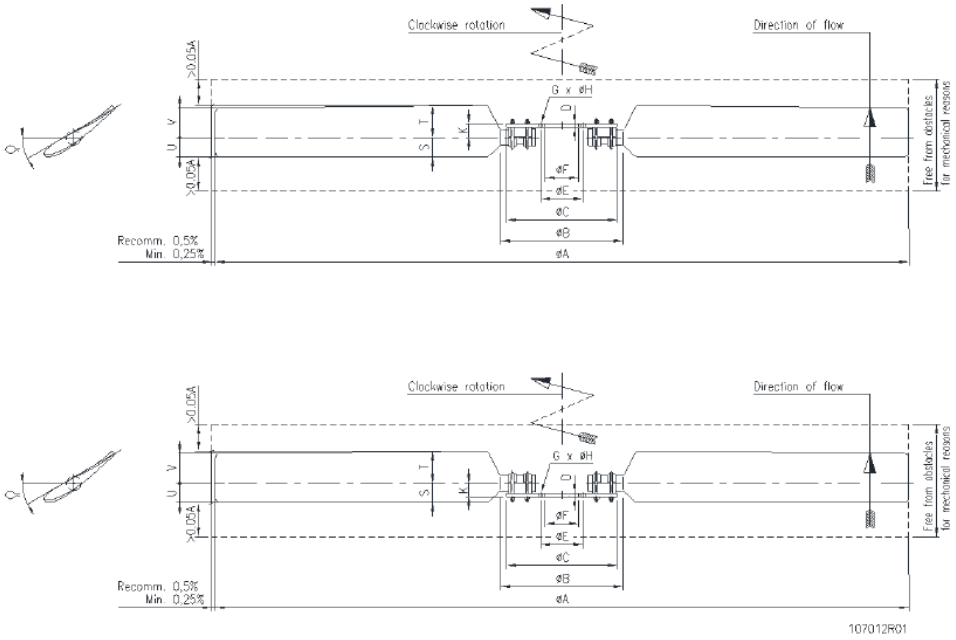
The sizing of the cooling tower fans has been carried out using the software provided by Howden, the supplier company.

Prior to this, it is necessary to define the following parameters:

- Airflow per cell.
- Temperature and humidity.
- Pressure.
- Air density.

These values have been entered into the software, which then selects the fan that fits the specified conditions.

The fan chosen is the 7920DLF5 with a diameter of 7,920 mm. The fan characteristics are shown in the following figure.



All sizes in mm

A	B	C	E	F	G*H	K	D	m [kg]	I [kg.m²]
7920	1050	1015	340	250	8*33	150	45	809	2078.4

Coupling flange (optional)	
Type	**Bore**
250D	Cylindrical, with key way
	Conical, suitable for split taper bushing(s): U1 (5.499 in)

Blade angle data				
α [°]	S	T	U	V
5.0	78	174	75	128

Figure 8.14. Fan dimensions.

The fan specification sheet can be located in Annex 5.1.

8.3.10 Fan cylinder

The selection of a specific fan cylinder for the cooling tower is based on the information in the catalogue provided by the manufacturer.

In the selection process, the diameter of the fan, which is 7,920 mm, has been considered. The following figures show the dimensions to consider and the selection catalogue.

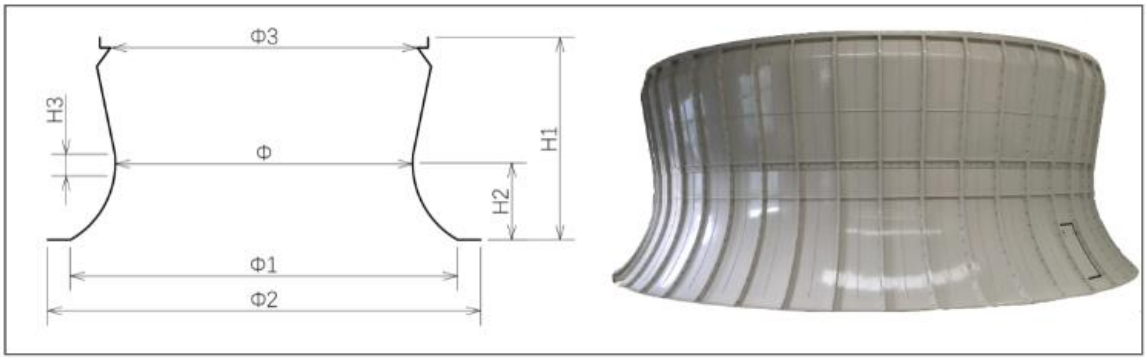


Figure 8.15. Fan cylinder dimensions scheme.

Modelo	H1 (mm)	H2 (mm)	H3 (mm)	Φ (mm)	Φ3 (milímetros)	Φ1 (mm)	Φ2 (mm)	Números de piezas por set
NFS-4.7-2.2	2200	1200	300	4760	4890	5664	5844	24
NFS-5.0-2.2	2200	1200	300	5060	5190	5964	6144	28
NFS-5.5-2.2	2200	1200	300	5520	5650	6424	6604	28
NFS-6.0-2.2	2200	1200	300	6060	6190	6964	7144	32
NFS-4.7-3.0	3000	1200	300	4760	4998	5664	5844	24
NFS-5.0-3.0	3000	1200	300	5060	5298	5964	6144	28
NFS-5.5-3.0	3000	1200	300	5520	5758	6424	6604	28
NFS-6.0-3.0	3000	1200	300	6060	6298	6964	7144	32
NFS-7.0-3.0	3000	1200	300	7060	7298	7964	8144	36
NFS-7.7-3.0	3000	1200	300	7760	7998	8664	8844	40
NFS-8.0-3.0	3000	1200	300	8070	8308	8974	9154	40
NFS-8.5-3.0	3000	1200	300	8610	8848	9514	9694	44
NFS-7.0-3.8	3800	1650	400	7060	7404	8472	8652	36
NFS-7.7-3.8	3800	1650	400	7760	8104	9172	9352	40
NFS-8.0-3.8	3800	1650	400	8070	8414	9482	9662	40
NFS-8.5-3.8	3800	1650	400	8610	8954	10022	10202	44
NFS-9.14-3.8	3800	1650	400	9220	9564	10632	10812	48
NFS-9.75-3.8	3800	1650	400	9834	10178	11246	11426	48
NFS-10.36-3.8	3800	1650	400	10460	10804	11872	12052	52

Figure 8.16. Catalogue table for fan cylinder selection.

The NFS-8.0-3.0 model has been selected due to its optimal compatibility with the fan diameter and the dimensions of the fan cylinder, which ensures efficient airflow circulation through the tower. The appropriate choice of the fan cylinder is essential to ensure optimal operation of the entire cooling system and maximize the tower efficiency in heat dissipation.

8.3.11 Motor

For the operation of the fan, a motor capable of supplying the appropriate power has been required. From the fan specifications sheet, the following information has been obtained:

- Power: 49.6 kW
- Speed: 123.3 rpm

In the SIEMENS motor catalogue, a motor with a corrosion-resistant epoxy paint coating has been selected. [23]

The motor 1LE0141-2CC76-4AA4 has been chosen. The technical data of the selected motor are:

- Rated power: 55 kW
- Speed: 1,185 rpm
- Number of poles: 6

8.4 Sizing of pumps

The sizing for the two pump systems needs to be calculated: one for the recirculating system and another for the makeup water. For the selection of the recirculating pumps, a 2+1 system will be used, meaning two pumps will be in continuous operation and one will be on standby.

Given the recirculating flow rate of 2,500 m^3/h and accounting for a design margin of 10% above the nominal flow rate, the design for each pump has been made with a total nominal flow rate of 1,375 m^3/h.

For a system pressure supply of 5 bar (50 m head), the Flowselex application by Flowserve has been used to select a pump that best fits the system requirements. A Mark 3 Sealmatic centrifugal pump has been chosen. [24]

Figure 8.17. Pump model.

The selected pump is suitable for the flow rate and discharge height conditions, as well as the characteristics of the fluid i.e., temperature, density, and viscosity. Below, Figure 8.18 shows the characteristic curves for the chosen pump.

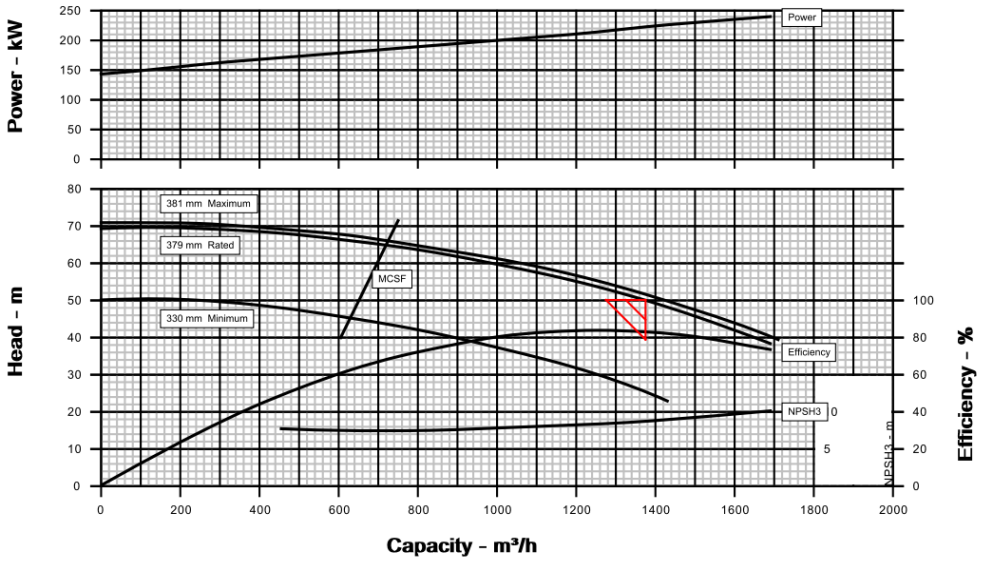


Figure 8.18. Characteristic curves recirculating pump.

In Annex 5.3, the pump specification sheet can be observed.

For the selection of the make-up water pumps, a 1+1 system will be used, meaning one pump will be in continuous operation while the other is on standby.

Considering the make-up water flow rate of 30.85 m^3/h and accounting for a 10% design margin above the nominal value, the design has been carried out for a pump with a total nominal flow rate of 34 m^3/h.

Using the Grundfos catalogue, the appropriate pump type has been selected. [25]

The Magna3 80-120F model has been chosen as it is a common pump model used for cooling tower applications. This pump is suitable for the system conditions.

Figure 8.19. Magna3 80-120F pump.

Figure 8.21 shows the characteristic curves of the chosen pump. Annex 5.4 shows the pump specification sheet.

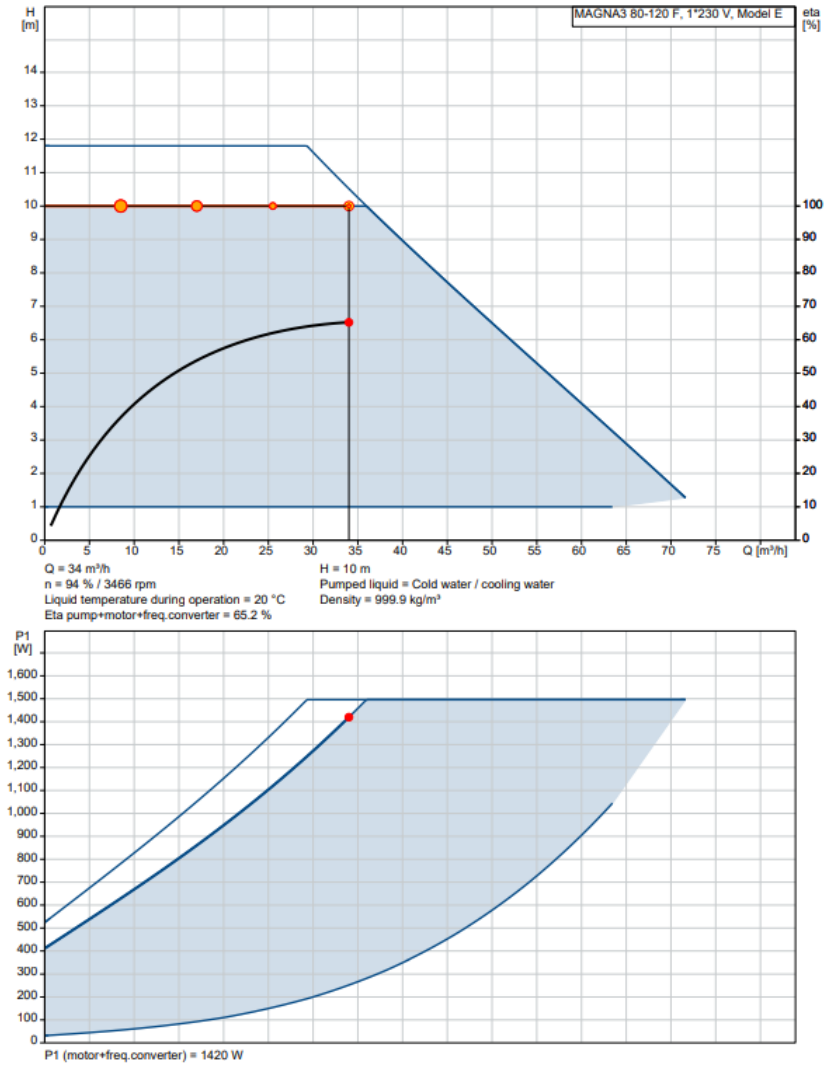


Figure 8.20. Characteristic curves make-up pump.

8.5 Chemical injection system

In this section, the design of the chemical dosing system has been included. Section 12 will define each of the products and provide detailed information about their functionality. [1]

Both products intended for stabilization treatment i.e., corrosion and scaling, and for microbiological control will be contained within a Portafeed Senior container, which will be designed based on the compatibility of the product with the materials. Depending on the required consumption, Portafeed Junior containers units of 1,000 kg will be supplied for the product transferring.

Figure 8.21. Product transfer from Portafeed Junior to Senior.

Sodium hypochlorite and sulfuric acid will be supplied through Intermediate Bulk Containers (IBCs).

Figure 8.22. IBCs NaClO and H2SO4.

Both PFs and IBCs contain hazardous substances, and during transfers, product spills could occur. To prevent any incidents that could suppose occupational and/or environmental risks, containment trays or spill containment pallets will be installed.

Figure 8.23. Spill containment.

For the chemical dosing, 8x5" PTFE tubing lines will be used. This material has been chosen due to its excellent chemical resistance along with optimal mechanical and thermal strength.

Figure 8.24. Tubing PTFE.

To select the dosing pumps, pump materials must be compatible with the substance to be dosed. Incorrect selection may affect the lifespan or proper operation of the equipment.

One pump will be selected for each chemical, and a 1+1 system will be used for dosing hypochlorite and sulfuric acid. This system is necessary since a cooling tower cannot be left without either acid or hypochlorite.

From the Grundfos catalogue [25], different types of pumps have been selected. Diaphragm dosing pumps will be used as they are optimal for precise chemical injection. The DDC pump range from Grundfos provides high precision at low flow rates and high pressures. Automatic flow control can be achieved using a frequency converter or by adjusting the stroke of the dosing pump. The following figure illustrates the type of pump chosen.

Figure 8.25. DDC dosing pumps.

The specification sheet of each pump is available in Annexes 5.5, 5.6, 5.7.

Furthermore, in the drawings document, drawing number 2, the location of the chemical area is indicated.

9 Instrumentation

Sensors and analysers play a crucial role in monitoring and controlling the cooling tower system. These devices collect data on various variables and parameters to assess tower performance and make control decisions. The most commonly used ones are temperature, level, pressure, flow, and water quality instruments. [25]

In Annex 6, the list of all system instruments can be found.

In the drawing document, diagram number 2 contains the P&ID of the system.

9.1 Level

The level transmitter is a device used to measure and control the water level in the cooling tower basin. It provides information about the available water volume and is used to regulate recirculation and make-up water supply. To select the optimal level transmitter, the following characteristics must be ensured:

- Good corrosion resistance: Since the transmitters are in contact with water, they need to be corrosion-resistant to maintain accuracy and durability.
- Suitable measuring range: They must have a measuring range compatible with the height of the water level in the cooling tower.
- Protection against water ingress: They should have measures to protect against water entering the transmitter.
- Compatibility with harsh environments: The transmitters must withstand adverse environmental conditions such as high temperatures, humidity, and vibrations.

In the Siemens catalogue, a radar level transmitter model SITRANS LR250 has been selected. This transmitter meets the aforementioned requirements. It is a level meter suitable for outdoor applications such as a cooling tower basin.

- Measuring range: 0-10 m
- Power supply: 24 VDC
- Output: 4-20mA/HART
- Accuracy: ± 2 mm

Figure 9.1. SITRANS LR250 level transmitter.

9.2 Temperature

This transmitter measures the water temperature within the tower. It provides information about cooling efficiency and helps control water flow and fan speed. Three transmitters have been selected: one to be installed at the cooling tower inlet, another at the outlet, and the last one on the make-up line. All three transmitters will have the same technical specifications and will work within the temperature range of 10-80°C.

A temperature transmitter in this type of application has the following characteristics:

- Wide measuring range to accommodate temperature variations typically encountered in cooling towers.
- Corrosion resistance resulting from contact with water and humid environments.
- Protection against water and dust ingress, with an IP65 protection level.

From the SIEMENS catalogue, the SITRANS TS500 sensor has been chosen. This sensor offers suitable working conditions for this application. Below are the technical specifications of the transmitter:

- Measuring range: 0-100°C.
- Protection level: IP65
- Power supply: 24VDC
- Output: 4-20mA/HART.

Figure 9.2. SITRANS TS500 temperature transmitter.

9.3 Flow

The flow transmitter measures the amount of water flowing through the cooling system. It helps to ensure proper water flow and allows for adjustments based on cooling demand. A total of 4 sensors have been selected and installed: on the inlet and outlet lines of the cooling water, on the make-up line, and on the blowdown line. Each sensor should cover the required flow conditions for its respective line.

The vortex flowmeter is the most suitable option for the system conditions. This type is highly compatible with corrosive liquids since, the circulating water contains chemical additives to prevent corrosion and bacterial growth.

From the Siemens catalogue, the SITRANS FX330 model has been selected. It is a vortex flowmeter that is ideal for measuring liquids, gases, and vapours regardless of their conductivity, viscosity, temperature, and pressure.

Figure 9.3. SITRANS FX330 flowmeter.

9.4 Pressure

The pressure sensor monitors the water pressure at different points in the system. It helps to maintain proper flow and optimize system efficiency.

Two pressure transmitters have been selected for location on the make-up line and at pump discharge.

From the SIEMENS catalogue, the SITRANS P DS III transmitter has been chosen. The technical specifications are as follows:

- Measurement range: up to 16 bar.
- Protection level: IP65
- Power supply: 24VDC
- Output: 4-20 mA/HART.

Figure 9.4. SITRANS PDS III pressure transmitter.

9.5 Water quality

Water quality analysers monitor parameters such as pH, conductivity, chlorine levels, corrosion rate, and chemical substance concentration in the water. This enables precise control of circulating water quality and helps prevent issues like corrosion, scaling, or bacterial growth.

The residual chemical concentration and corrosion rate is monitored using the 3DTrasar equipment supplied by Nalco Water. A detailed description of the operation of this equipment is beyond the scope of this project due to the confidentiality of the company's information.

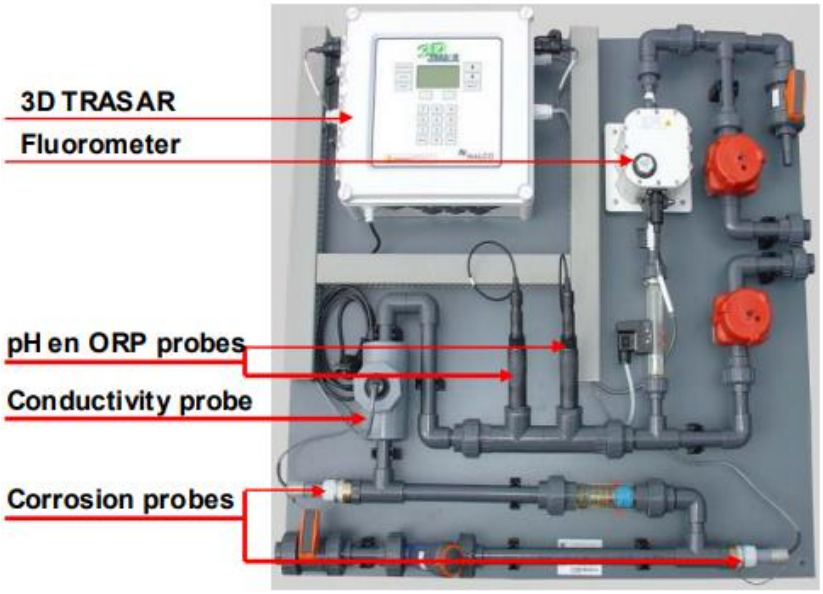


Figure 9.5. 3DTrasar equipment by Nalco Water.

The readings of pH, conductivity, and chlorine values are taken both at the control panel and at a designated onsite location to ensure comprehensive monitoring of system conditions. An analyser booth is installed near the cooling tower for the local reading of these variables.

An analyser booth is a space or enclosure designed to house the various analysers and monitoring equipment used in the control and supervision of a cooling tower.

9.5.1 pH analyser

pH monitoring is crucial for the operation of the cooling system, as an optimal pH value ensures process efficiency and safety. The characteristics of a pH analyser include:

- Measurement range: between 6-9 units.
- Precision and stability.
- pH sensors specifically designed to withstand the corrosive and humid conditions of tower water.
- Regular calibration is necessary to maintain measurement accuracy.

Three pH analysers are required, with two installed on the inlet lines to the cooling tower and the third at the outlet.

9.5.2 Conductivity analyser

The conductivity analyser is used to measure the electrical conductivity of the water in the tower. It is related to the concentration of salts and other ions dissolved in the water. Monitoring this parameter is important to maintain good water quality and prevent corrosion/scaling issues.

The characteristics of a conductivity analyser are the same as those for the pH analyser. Three conductivity analysers are installed, located on the same lines as the pH analysers.

9.5.3 Chlorine analyser

The chlorine analyser is a device used to measure the concentration of chlorine in the tower water. Chlorine is commonly used as a disinfectant to control the growth of microorganisms, such as bacteria and algae, in the cooling system. Maintaining an appropriate level of chlorine is essential to ensure hygiene and prevent biological hitches in the tower.

An analyser with a suitable measurement range has been selected to cover the typical values of chlorine used in the cooling system. Typical chlorine levels in a cooling tower range from 0.5-1 ppm. However, an analyser with a range between 0-5 ppm has been chosen, as during Legionella disinfections, the chlorine concentration is raised to 5 ppm. This way, better control of the biocide will be achieved. Additionally, it is important for the analyser to have proper calibration and regular maintenance to ensure accurate and reliable measurements.

9.5.4 Summary table

Table 9.1 shows a summary of installed sensors and analysers in the cooling tower.

Table 9.1. Summary table.

Component	Instrument type	Measured parameter	Purpose	Location
Flow	Flow meter	Circulating water flow	Flow monitoring	Make-up, cooling water inlet and outlet, and blowdown.
Temperature	Temperature transmitter	Water temperature	Temperature control	Make-up and cooling water inlet and outlet.
Pressure	Pressure transmitter	System pressure	Pressure monitoring	Make-up and pump discharge
Level	Level sensor	Water level in the tower	Control and safety	Basin
pH	pH electrode	Acidity or alkalinity	Chemical control	Make-up and cooling water inlet and outlet.
Conductivity	Conductivity meter	Electrical conductivity	Concentration control of salts	Make-up and cooling water inlet and outlet
Chlorine	Chlorine analyser	Chlorine concentration	Biocide monitoring	Cooling water outlet

10 Electrical installation

The electrical installation section in a chemical plant encompasses four main areas:

- Fire Protection: Design of various fire detection systems, alarms, and automatic extinguishing systems to prevent and efficiently control fires.
- Lighting: Arrangement of appropriate lighting systems.
- Power: Power supply to pumps, motors, etc.
- Electronic equipment, control and automation systems, as well as communication and monitoring systems.

Due to the current lack of information about the consumption of several major units that also require a significant power, these four areas are beyond the scope of this project. It is recommended that planning and execution of the electrical installation to be considered separately in the future.

10.1 Scope

The purpose of this project is to design a new cooling tower for the expansion of the chemical plant capacity. The cooling tower will meet the cooling water demands generated by the upcoming units to be implemented. These units, which will include components such as heat exchangers, reactors, compressors, and process pumps, will require certain levels of energy consumption.

Since these data are not available, it is not possible to perform a complete design of the electrical installation. For this reason, elements such as the design of a transformer station, the electrical supply, and the main protection panel are beyond the scope of this project. In this project, only a partial load forecasting for the cooling tower area is provided.

10.2 Partial load forecasting for the new unit

In this section, a partial load forecasting has been carried out for the components where the electrical consumption is known. As mentioned in the previous section, the consumption for example of the heat exchangers and reactors is unknown.

Table 10.1. Partial load forecast.

Equipment	Power
Recirculation pump 1	240,000 W
Recirculation pump 2	240,000 W
Recirculation pump 3	240,000 W
Make-up pump 1	1,500 W
Make-up pump 2	1,500 W
Fan motor 1	55,000 W
Fan motor 2	55,000 W
Corrosion inhibitor pump	22 W
Dispersant pump	22 W
Non-oxidizing biocide pump	22 W
Biodetergent pump	22 W
Hypochlorite pump 1	22 W
Hypochlorite pump 2	22 W
Sulfuric acid pump 1	22 W
Sulfuric acid pump 2	22 W
TOTAL:	**833,133 W**

Therefore, the estimated partial power requirement for this new unit is 833 kW.

11 Startup

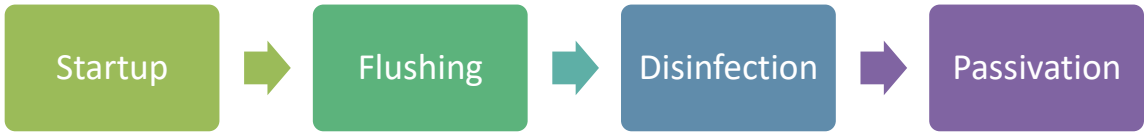


Figure 11.1. Startup process diagram.

11.1 Scope

One of the critical steps in protecting the cooling circuit during system shutdown and startup is the way this is prepared and executed. The prevention of corrosion, minimization of microbiological growth, fouling, and scaling are the main foundations of a good program. [1]

Following the best practices there are different options mainly differentiated by the duration of the shutdown:

1. Maintenance of the circuit in recirculation for shutdowns < 30 days.
2. Draining the system for shutdowns > 30 days and/or when lines/equipment need to be intervened for maintenance. If it is necessary to completely drain the circuit, it should be ensured that the lowest points of the circuit are well purged, avoiding water stagnation at certain points. Nevertheless, as a preventive measure, it is advisable to reinforce the chemical and microbiological treatments to enhance the protection of the system against corrosion, scaling, and the presence of bacteria. In the startup, a global passivation of the circuit should be carried out, as well as a disinfection for Legionella.
3. Water stagnation. This option is less recommended since stagnant water is susceptible to promoting significant corrosion and microbiological growth phenomenon.

Since this project concerns the startup of the system, and as it does not contain water in the circuit, option 2 has been considered.

11.2 Flushing

Flushing during startup is the process of cleaning and purging the system to remove impurities, sediments, and potential contaminants before starting up the tower. It helps to ensure optimal performance and prevents subsequent hitches in the cooling system. The following table shows the procedure.

Table 11.1 Applied procedure for system flushing.

Step	Action
1	**Fill the system with water.** Fill the tower to an appropriate level for circulation.
2	**Keep the system in circulation for at least 2 hours.**
3	**Initial sample collection.** Collect water sample for initial parameter characterization (pH, conductivity, and iron). - If iron concentration is less than 1 ppm ➔ Proceed to step 4. - If iron concentration is higher than 1 ppm ➔ Empty the system and return to step 1 to achieve an iron concentration value below 1 ppm.
4	Proceed with system **disinfection**.

11.3 Disinfection Legionella according to RD

The procedure described in Royal Decree 487/2022 will be carried out. This requires the semestral implementation of a "cleaning and disinfection treatment for industrial cooling towers" as a preventive measure for Legionellosis control.

11.3.1 Procedure

1. Chlorination of the system for up to 5 ppm of residual chlorine, addition of biodispersant and corrosion inhibitor while maintaining a pH between 7-8. A non-oxidizing biocide shock will be added as a reinforcement.
2. Close the blowdown if necessary to maintain residual chlorine of up to 5 ppm.
3. Products used. The products required to carry out the cleaning and disinfection of the cooling tower are shown in the following table.

Table 11.2. Products and doses of the products used.

Product	Dose
Biodispersant	20 ppm
Oxidizing biocide (NaClO)	50 ppm
Non-oxidizing biocide	200 ppm

4. Recirculation of the system for 4 hours with the fans disconnected when it is possible to avoid aerosol release. Chlorine level will be measured every hour to maintain the 5 ppm.
5. After the 4 hours, renew with fresh water to the extent possible. Return to the normal biocide residual control, in this case, 0.5 ppm chlorine.
6. Perform mechanical maintenance operations on the equipment and repair any faults detected.
7. After 15 days of treatment, a water sample will be taken for analysis in an accredited external laboratory to determine Legionella Pneumophila.

11.4 Passivation

The initial passivation of the metal is the key point to achieve an effective treatment program performance. [1]

Non-passivation or incomplete passivation of the metal surface will result in rapid corrosion once startup has been carried out. This phenomenon is often known as "flash corrosion." The resulting products are generally loose and porous deposits that contribute to reducing heat transfer efficiency. Additionally, they interfere with the effectiveness of corrosion inhibitors, hindering proper interaction at the point of the surface where this corrosion is produced.

The basic concept for effective metal passivation is simple. In essence, the process consists of four steps:

1. To prepare the metal surface to be receptive to the formation of a corrosion inhibiting film.

2. To create a corrosion inhibiting film before "flash corrosion" occurs.

3. To complete metal passivation and repair any breaks in the initial inhibiting film formed.

4. To maintain the inhibiting film.

The following table shows the steps to be followed to carry out the passivation procedure of the cooling tower.

Table 11.3. Procedure applied to system passivation.

Step	Action
1	**Initial sample collection.** Water sample will be taken for initial parameter characterization (pH, iron, copper, hardness, conductivity, and microbiological count).
2	**Adjust operation conditions to start passivation.** Start recirculation of the water only through main lines and adjust: ▪ pH: set pH setpoint between 7.8 – 8.0. ▪ Chlorine: set chlorine setpoint between 0.2 – 0.4 ppm
3	**Once setpoints are reached, chemical shocks are performed to passivate the system.**
4	**Keep the system in recirculation for at least the next 48-72 hours.** Periodically, samples will be taken to monitor the evolution of iron and turbidity. After 24 hours, if a total iron residual increase >3 ppm is observed, adjust blowdown to target the value of 3 ppm as the upper limit. Adjust blowdown to maintain iron levels below 1 ppm. Presumably, the lateral filter will help deconcentrate iron in the system.
5	**After 48 hours on finding iron within specifications, the passivation process will be considered complete.**
6	**Adjust operation parameters (system normalization).** - Set pH setpoint between 7.4-7.6 units. - Set chlorine setpoint between 0.5-1 ppm. - Normalize the chemical treatment dosage.

11.4.1 Chemical products

- **Dispersant.** Dispersing product that allows fouling control in cooling systems. This chemical is especially effective at dispersing/emulsifying oils and, therefore, preventing the formation of oily deposits in the circuit.
- **Corrosion inhibitor.** Corrosion inhibitor for carbon steel used for cooling waters in both open and closed systems.

- **Cathodic corrosion inhibitor and calcium carbonate dispersant.** Dual-function chemical used as a cathodic corrosion inhibitor and calcium carbonate dispersant in open cooling systems.

- **Biodetergent.** Product with biodispersant properties complementary to chlorination, as its basic principles are derived from surfactants. It will help eliminate the biofilm that may be present in some of the heat exchangers. Similarly, the biodetergent helps make chlorination more effective, as oxidizing biocides attack superficially on contact and do not penetrate the interior. Likewise, the biodetergent will keep the fill clean so that tower efficiency will be maximized.

- **Non-oxidizing biocide.** Broad-spectrum non-oxidizing biocide for bacteria control during cooling system lay-up.

- **Sodium hypochlorite.** Chlorine source acts as an oxidizing biocide.

- **Sulfuric acid.** This will be required to keep the pH under control, avoiding excursions that could favour increased corrosion or deposition of suspended particles.

12 Chemical treatment

The proposed chemical treatment aims to achieve effective control of scaling, corrosion, and microbiological growth, in order to ensure optimal system operation. It also aims to provide cooling water of sufficient quality for reuse, thereby optimizing water consumption. [1]

To ensure optimal circulation water quality, the monitoring of various control parameters defined as KCI (Key Control Indicators) is essential. These indicators provide information about the system status, while KPIs (Key Performance Indicators) focus on treatment performance. KCI and KPI definitions can be found in Annex 3.

In order to define the appropriate stabilization treatment (corrosion-scaling) for this cooling tower, the influent water quality and plant operating conditions have been studied. However, for proper operation, pH is the most critical parameter. For this system, a pH will be maintained to ensure maximum salt solubility and corrosion rates within the ranges set as KPI.

Regarding microbiological control, a treatment program will be employed based on the continuous application of an oxidizing biocide (sodium hypochlorite), a non-oxidizing shock biocide, and a biodetergent. The significance of this treatment is evident in the following points:

1. Microorganisms can reduce heat transfer due to organic matter accumulation in exchange areas i.e., biofouling.
2. Microbiological fouling interferes with the action of corrosion inhibitors and can even lead to direct issues, such as with sulfate-reducing bacteria (Desulfovibrio).
3. Depending on the species, it can lead to environmental health problems due to the presence of Legionella Pneumophila in the system.

Table 12.1. describes the chemical products used and their function.

Table 12.1. Overview of the chemical treatment program used.

Chemical product	Function
Corrosion inhibitor	Cathodic and anodic corrosion and scaling inhibitor.
Dispersant	Control of calcium phosphate, iron aluminium, and suspended solids.
Biodetergent	Enhances microbiological control program efficiency and keeps the system clean.
Non-oxidizing biocide	Broad-spectrum non-oxidizing biocide.
Sulfuric acid	pH control. Neutralizes carbonates and bicarbonates in the water, preventing calcium carbonate precipitation.
Sodium hypochlorite	Oxidizing biocide. Acts on contact and effectively controls microbiological growth.

Annex 7 contains the MSDS for sodium hypochlorite and sulfuric acid from the Tarragona supplier Quifransa. MSDS for other products have not been included due to company confidentiality.

Annex 3.3 describes the water quality monitoring program and Annex 4 describes the maintenance procedures for the installation.

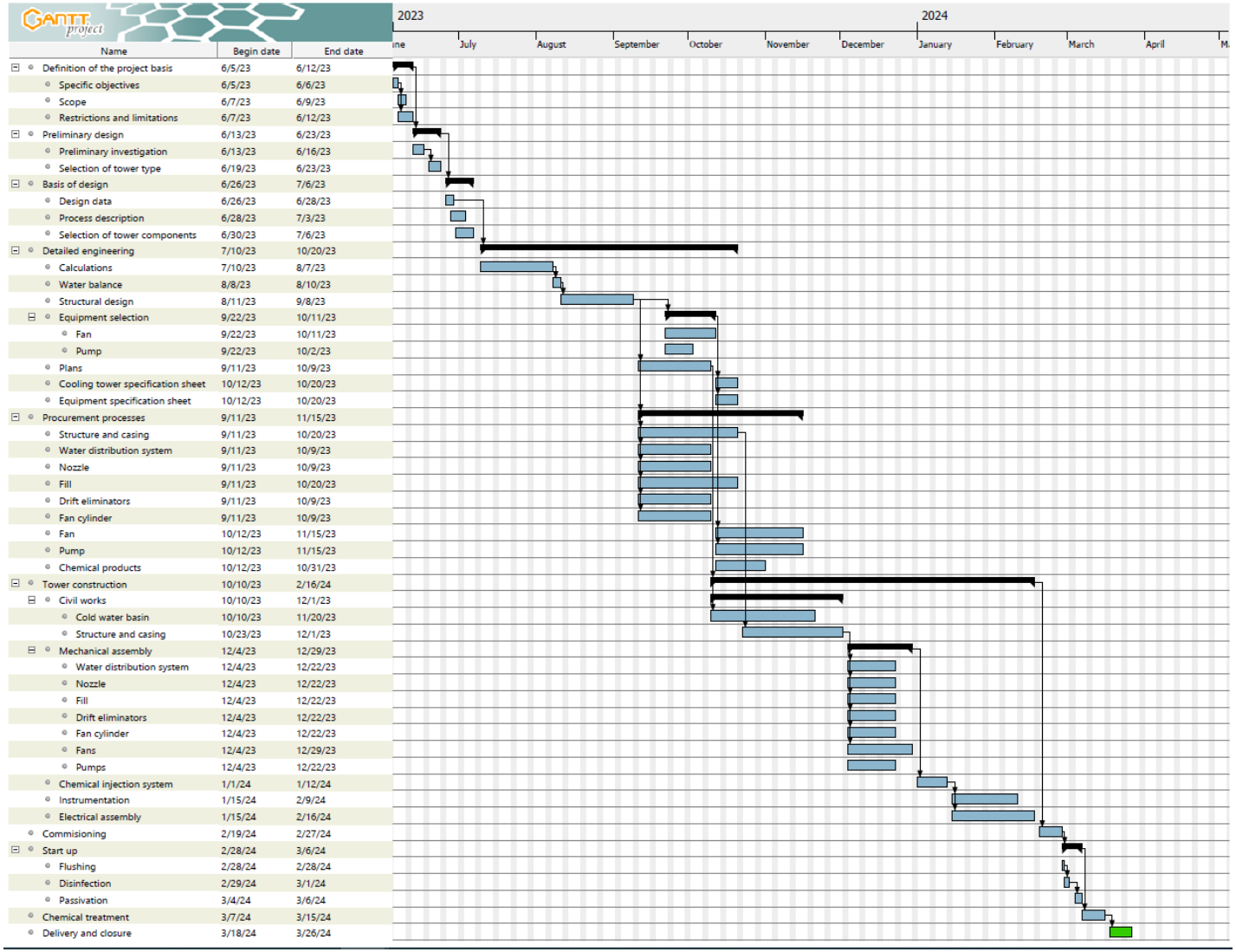
13 Planification

For the execution of this project, a Gantt chart has been created, illustrating the breakdown for each stage that comprising an engineering project. The project has been divided into various phases:

- Project basis definition: Different specific project objectives have been detailed, and the scope defined, identifying constraints and limitations.
- Preliminary design: Preliminary research has been carried out on different types of cooling towers in the market and the selection of a cooling system appropriate for cooling capacity and local climate factors.
- Design basis: Description of the operation process of the selected cooling tower and definition of its components.
- Detailed engineering: This phase involves developing detailed calculations, drawings, and technical specifications of the cooling tower. Materials, dimensions, and components to be used have been defined.
- Procurement process: Material required for constructing the new unit, such as distribution system, drift eliminators, fans, chemical products, etc., have been requested from different distributors.
- Tower construction: Site preparation and foundation, support structure construction, installation of tower components, chemical dosing systems, instrumentation, and electrical assembly.
- Commissioning: Verification of proper operation of all cooling tower systems and components, ensuring meeting requirements and standards before operation.
- Startup: System filling, flushing, disinfection, and passivation after commissioning.
- Chemical treatment: After startup, operational parameters will be adjusted, and regular chemical treatment will be initiated.
- Project delivery and closure: Official handover of the project to the client.

Once the different parts of this project have been defined, the estimated total duration for implementing the cooling tower, from start to operation, will last approximately 10 months.

The project execution diagram is shown in Figure 13.1.



Name	Begin date	End date
Definition of the project basis	6/5/23	6/12/23
Specific objectives	6/5/23	6/6/23
Scope	6/7/23	6/9/23
Restrictions and limitations	6/7/23	6/12/23
Preliminary design	6/13/23	6/23/23
Preliminary investigation	6/13/23	6/16/23
Selection of tower type	6/19/23	6/23/23
Basis of design	6/26/23	7/6/23
Design data	6/26/23	6/28/23
Process description	6/28/23	7/3/23
Selection of tower components	6/30/23	7/6/23
Detailed engineering	7/10/23	10/20/23
Calculations	7/10/23	8/7/23
Water balance	8/8/23	8/10/23
Structural design	8/11/23	9/8/23
Equipment selection	9/22/23	10/11/23
Fan	9/22/23	10/11/23
Pump	9/22/23	10/2/23
Plans	9/11/23	10/9/23
Cooling tower specification sheet	10/12/23	10/20/23
Equipment specification sheet	10/12/23	10/20/23
Procurement processes	9/11/23	11/15/23
Structure and casing	9/11/23	10/20/23
Water distribution system	9/11/23	10/9/23
Nozzle	9/11/23	10/9/23
Fill	9/11/23	10/20/23
Drift eliminators	9/11/23	10/9/23
Fan cylinder	9/11/23	10/9/23
Fan	10/12/23	11/15/23
Pump	10/12/23	11/15/23
Chemical products	10/12/23	10/31/23
Tower construction	10/10/23	2/16/24
Civil works	10/10/23	12/1/23
Cold water basin	10/10/23	11/20/23
Structure and casing	10/23/23	12/1/23
Mechanical assembly	12/4/23	12/29/23
Water distribution system	12/4/23	12/22/23
Nozzle	12/4/23	12/22/23
Fill	12/4/23	12/22/23
Drift eliminators	12/4/23	12/22/23
Fan cylinder	12/4/23	12/22/23
Fans	12/4/23	12/29/23
Pumps	12/4/23	12/22/23
Chemical injection system	1/1/24	1/12/24
Instrumentation	1/15/24	2/9/24
Electrical assembly	1/15/24	2/16/24
Commisioning	2/19/24	2/27/24
Start up	2/28/24	3/6/24
Flushing	2/28/24	2/28/24
Disinfection	2/29/24	3/1/24
Passivation	3/4/24	3/6/24
Chemical treatment	3/7/24	3/15/24
Delivery and closure	3/18/24	3/26/24

Figure 13.1. Project planification.

14 Priority order between the documents

The priority of the documents are as follows:

1. Report
2. Annex
3. Drawings
4. Budget

Xènia Balagué Trepat

Cooling Tower Design

Final Master Project
Adviser: Dr. Francisco González Molina

Master's degree in Industrial Engineering

Document 3: Annex

UNIVERSITAT ROVIRA I VIRGILI

Tarragona
2023

Index

1 Psychometrics

Psychometrics is a branch of science that studies the thermodynamic properties of moist air and the effect of atmospheric humidity on materials and human comfort. This air, known as moist air, is composed of a mixture of dry air and water vapour.

Dry air is a mixture of various gases. Its general composition is as follows:

- Nitrogen: 77%
- Oxygen: 22%
- Carbon dioxide and other gases: 1%

In relation to its temperature, air has the property of retaining a certain amount of water vapour. At lower temperatures, there is less vapour, and conversely, at higher temperatures, there is more water vapour, if the pressure is kept constant at atmospheric pressure.

To determine thermodynamic properties, a psychrometric chart has been used. It is a chart that allows you to evaluate the state of the air when some of the variables that relate to the mixture of air and water vapour change. A different chart can be used depending on altitude and pressure. The following figure shows a psychrometric chart.

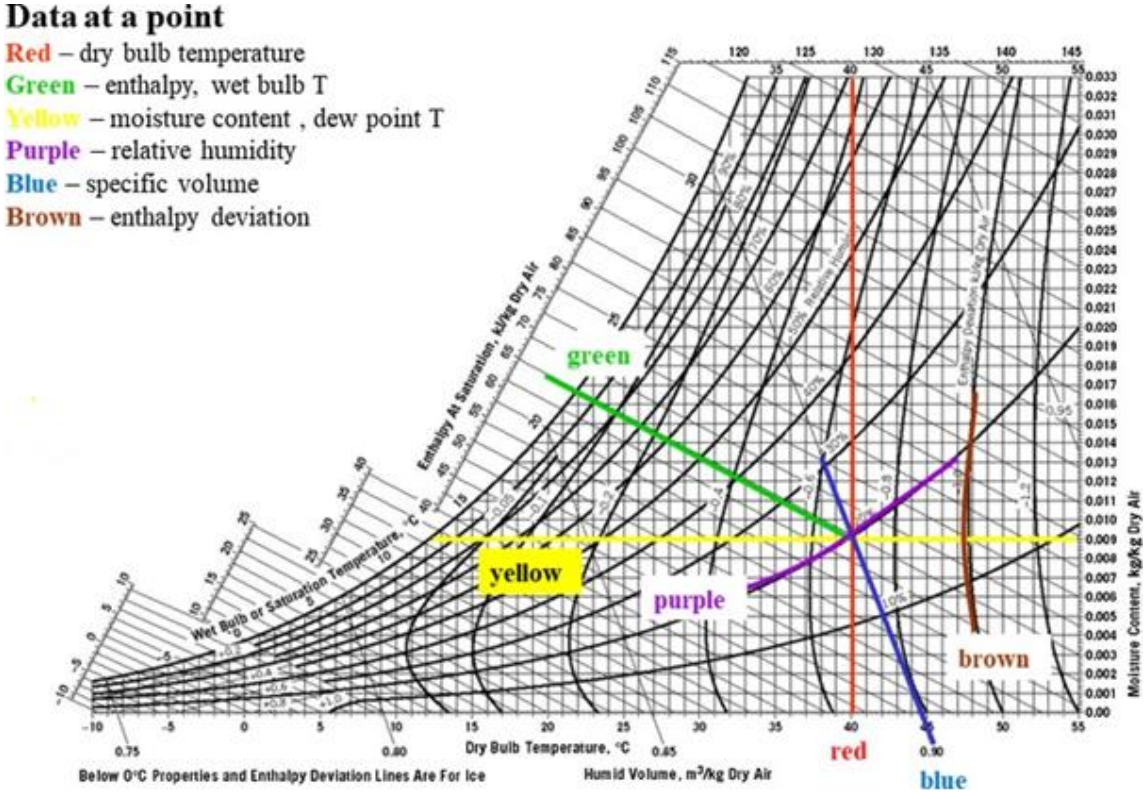


Figure 1.1 Psychrometric chart.

The parameters involved in evaluating moist air using the psychrometric chart are:

- Dry-bulb temperature: Represented on the horizontal axis of the psychrometric chart (shown as a red line). It is the temperature read from a common thermometer, measured in degrees Celsius (°C).

- Wet-bulb temperature: Calculated on the psychrometric chart by drawing a sloped line to the saturation curve and projecting its intersection onto the horizontal axis. Measured in degrees Celsius (°C).

- Dew point temperature: This is the temperature to which the air must be cooled for water vapour to begin condensing. A horizontal line is drawn from a given point to the saturation curve, and its projection on the horizontal axis has been determined.

- Specific humidity or humidity ratio (W): Determined on the graph along the vertical axis (represented in yellow on the graph). It represents the actual water content in the air, measured in grams of water vapour per kilogram of dry air (g/kg).

- Relative humidity (RH): It is the ratio of the water vapor pressure in the air (specific humidity W) to the saturation vapor pressure (Ws) that the air could hold at the same temperature. On the psychrometric chart, it is represented by purple curves that go from left to right and bottom to top. It is dimensionless, presented as a percentage.

- Saturation curve: Represents 100% relative humidity.

- Enthalpy: It is the amount of energy contained in the moist air at a temperature above zero degrees Celsius. The unit of measurement is kJ/kg of dry air. Enthalpy for a point on the chart has been calculated by projecting the sloped line to the enthalpy lines on the left side of the saturation curve. The green line in the figure represents this.

- Specific volume: This is the volume occupied by the air, measured in cubic meters per kilogram of dry air. Its units are m^3/kg. On the psychrometric chart, it is read using blue sloped lines originating from the right side of the horizontal axis, going from right to left and bottom to top.

2 Calculations

2.1 Calculation of fundamental parameters of the cooling tower

2.1.1 Inlet dry bulb temperature

Dry bulb temperature is the temperature measured in a dry environment, without humidity.

To determine this parameter, the dry temperatures average during the summer of 2022 in Tarragona has been calculated. Only these temperatures have been considered because the summer season is the most unfavourable for a cooling tower. It is more challenging to cool the water. In the following table, the dry bulb temperatures average for the hottest months can be observed.

Table 2.1. Dry bulb temperature in Tarragona in 2022.

	June	July	August
2022	23.3ºC	25.7ºC	26ºC

The reference value for the dry bulb temperature is the average, which has a value of 25°C. It is represented as p1 in Figure 2.1.

2.1.2 Inlet wet bulb temperature

Wet bulb temperature is the temperature reached by a small mass of liquid water submerged in a continuous stream of gas.

The inlet wet bulb temperature has been obtained from the dry bulb temperature (ambient temperature) and the relative humidity. The value has been obtained from the psychrometric chart at atmospheric pressure and sea level.

As shown in Figure 2.1, p2 represents the inlet wet bulb temperature, with a value of 21°C.

2.1.3 Approach

Another important parameter is the approach (a). It is the difference between the outlet cold water temperature of the cooling tower and the inlet wet bulb temperature of the air.

$$a = Tw_{out} - Twb_{in} \quad (1)$$

$$a = 26 - 21 = 5^{o}C \quad (2)$$

2.1.4 Range

The difference between the inlet hot water and outlet cold water temperature is known as the thermal range or temperature differential.

$$\Delta T = Tw_{in} - Tw_{out} \quad (3)$$

$$\Delta T = 32 - 26 = \ 6^{o}C \quad (4)$$

2.1.5 Outlet dry and wet bulb temperature

The outlet wet bulb temperature ($Twb_{,out}$) is the same as the outlet dry bulb temperature ($Td_{,out}$) because air saturation occurs, and this is also the inlet dry bulb temperature plus the approach.

$$Twb_{out} = Td_{out} = Td_{in} + a \quad (5)$$

However, it is important to consider that there are losses due to entrainment (0.01%) and other factors that affect the tower outlet temperature. Therefore, the outlet wet bulb temperature has been calculated as follows:

$$Twb_{out} = 0.999 * (Td_{in} + a) \quad (6)$$

$$Twb_{out} = 0.999 * (25 + 5) = 30^{o}C \quad (7)$$

The values of wet bulb and dry bulb temperatures at the outlet correspond to point p3 in Figure 2.1.

2.1.6 Other parameters

Once the inlet and outlet dry and wet bulb temperatures have been defined, the same program is also providing us with other fundamental parameters, such as humidity ratio, dew point temperature, humid air densities, inlet and outlet enthalpies and specific volumes. Table 2.2. shows the results.

Table 2.2. Fundamental parameters extracted from the psychrometric chart.

Parameter	Symbol	Value
Inlet humidity ratio (g/kg dry air)	W_{in}	13.9
Outlet humidity ratio (g/kg dry air)	W_{out}	27.2
Dew point temperature (ºC)	Tr	19.1
Inlet enthalpy (kJ/kg dry air)	h_{in}	60.6
Outlet enthalpy (kJ/kg dry air)	h_{out}	99.7
Inlet specific volume (m3/kg dry air)	v_{in}	0.8635
Outlet specific volume (m3/kg dry air)	v_{out}	0.8964
Inlet humid air density (kg/m3)	$\rho_{wa\,in}$	1.1742
Outlet humid air density (kg/m3)	$\rho_{wa\,out}$	1.1460

From the inlet and outlet humid air density, the dry air density can also be determined using the following equation:

$$\rho_{da} = \rho_{wa} \cdot \chi_{da} \quad (8)$$

Where the fraction of dry air is:

$$\chi_{da} = \frac{1}{1+W} \quad (9)$$

Therefore, the inlet density of dry air of the cooling tower will be:

$$\rho_{da,in} = 1.1742 \cdot \frac{1}{1+0.0139} = 1.1581 \frac{kg\ d.a}{m^3} \quad (10)$$

And the outlet:

$$\rho_{da,out} = 1.1460 \cdot \frac{1}{1+0.0272} = 1.1157 \frac{kg\ d.a}{m^3} \quad (11)$$

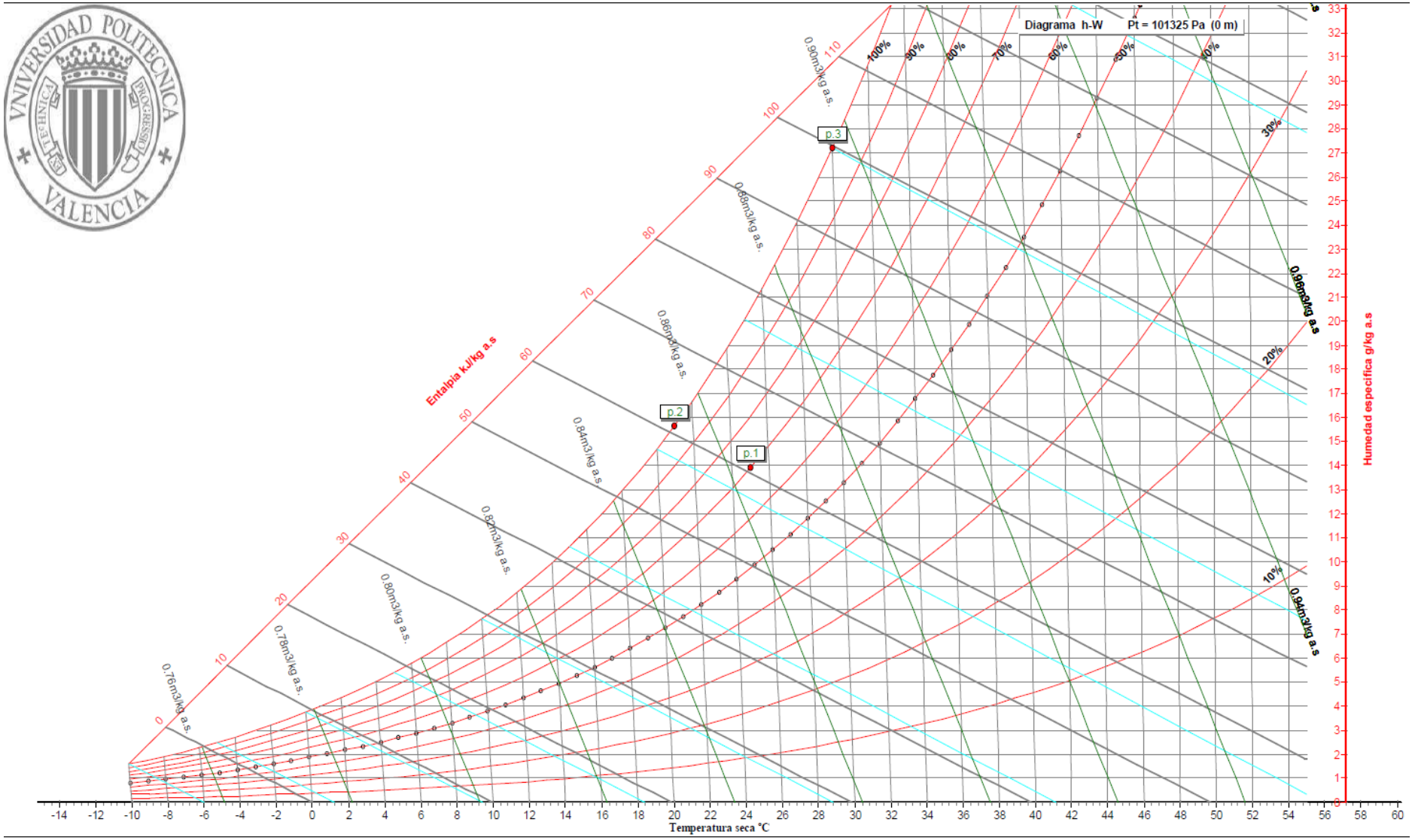


Figure 2.1. Determination of fundamental parameters using the psychrometric chart.

2.1.7 Calculation of L/G ratio

The L/G ratio of a cooling tower is the relationship between the water and the air flow circulating through the cooling circuit. It is the fundamental basis for determining the characteristic curve of a cooling tower. To obtain this value, it is necessary to perform an energy balance on a differential surface of the fill. To do this, one must first understand how heat is transferred from water. Heat from water is transferred in three ways:

- Through radiation (q_R). Heat is transferred through the external surface of the drop, which heats the interface. It is considered negligible due to its low thermal level.
- Through conduction (q_C). The amount transferred depends on the temperature difference between the two phases, reaching at most one-third of the total heat achieved.
- Through the evaporation (q_e) of a quantity of water. This is the most important process.

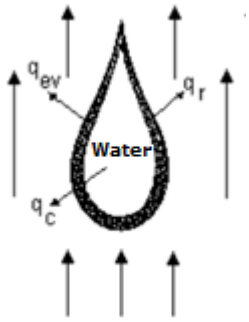


Figure 2.2. Transfer process diagram of a drop.

The following variables have been defined and shown in Table 2.3.

Table 2.3. Definition of initial variables.

Variable	Symbol	Unit
Inlet water flow	L	kg/h
Inlet water temperature	Tw_{in}	ºC
Outlet water temperature	Tw_{out}	ºC
Make-up water temperature	T_m	ºC
Make-up water flow	W	kg/h
Inlet air flow	G	kg/h
Inlet air enthalpy	h_{in}	kJl/kg
Outlet air enthalpy	h_{out}	kJ/kg
Specific heat of water	C_{pw}	kJ/kg ºC

The general energy balance of the system has been defined as:

$$L \cdot C_{pw} \cdot Tw_{in} + G \cdot h_{in} + W \cdot C_{pw} \cdot T_m = L \cdot C_{pw} \cdot Tw_{out} + G \cdot h_{out} \qquad (12)$$

And the energy balance on a differential surface of the fill:

$$dq = L \cdot C_{pw} \cdot dt = G \cdot dh \tag{13}$$

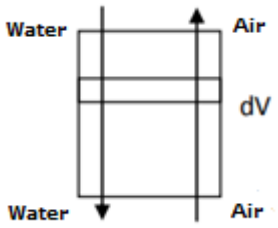


Figure 2.3 Energy balance on a differential surface of the fill.

As observed in equation 13, the heat given off by the water is equal to the heat absorbed by the air.

$$L \cdot C_{pw} \cdot (T - Tw_{out}) = G \cdot (h - h_{in}) \tag{14}$$

Isolating the enthalpy (h) in the equation:

$$h = \frac{L}{G} \cdot C_{pw} \cdot T + (h_{in} - \frac{L}{G} \cdot C_{pw} \cdot Tw_{out}) \tag{15}$$

The above equation represents the equation of a line with a slope of $\frac{L}{G} \cdot C_{pw}$ and a y-intercept of $h_{in} - \frac{L}{G} \cdot C_{pw} \cdot Tw_{out}$. This is the operating line.

The operating line of the system has been represented by the inlet and outlet water temperatures and the inlet and outlet air enthalpies.

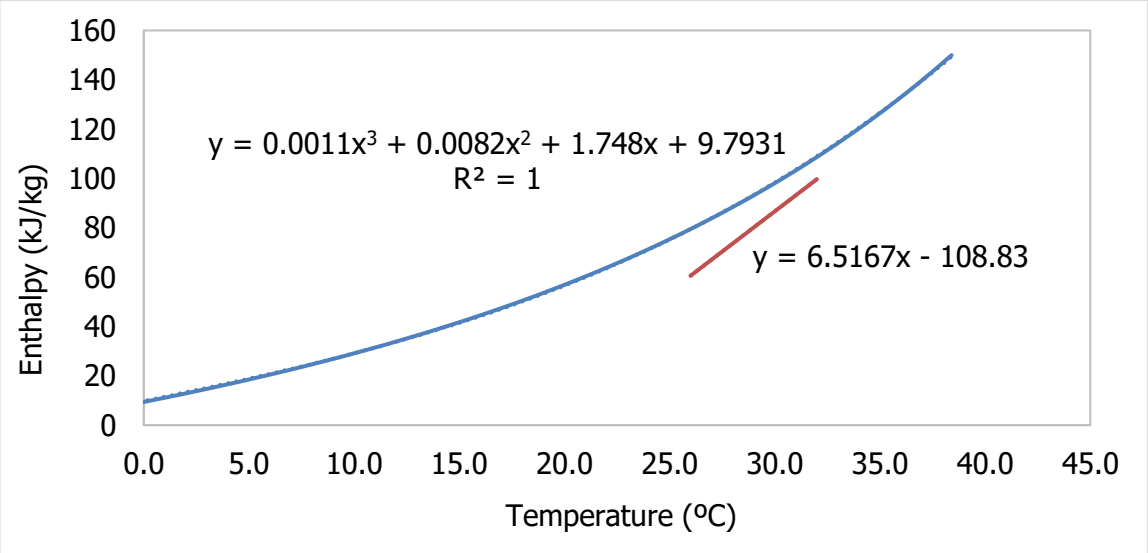


Figure 2.4. Cooling tower operation diagram, graph of enthalpy vs. temperature.

To obtain the L/G ratio, the value of the slope has been equated with $\frac{L}{G} \cdot C_{pw}$.

$$slope = \frac{L}{G} \cdot C_{pw} \tag{16}$$

$$\frac{L}{G} = \frac{6.5167}{4.181} = 1.559 \tag{17}$$

2.1.8 Number of transfer units

Finally, the Number of Transfer Units (NTU) has been determined. It can be said that the transfer unit is an index of the absorption required to meet the cooling tower requirements.

Starting from equation 13:

$$dq = L \cdot C_{pw} \cdot dt = G \cdot dh = dq_{conduction} + dq_{evaporation} \quad (18)$$

The heat of conduction has been defined by Fourier's law:

$$dq_{conduction} = h_c \cdot a \cdot dV \cdot (T' - T) \quad (19)$$

where:

hc: film coefficient (kcal/h m2 ºC)

a: contact surface area for air-water per unit volume

V: volume of the fill

T': interface temperature of air-water

T: air temperature

The heat of evaporation has been defined as follows:

$$dq_{evaporation} = k \cdot (x_s - x) \cdot a \cdot dV \cdot \lambda_v \quad (20)$$

Where:

k: mass transfer coefficient, amount of mass transferred between water and air per unit area and unit difference in specific humidities

a: contact surface area for air-water per unit volume

V: volume of the fill

xs: specific humidity of the air-water interface

x: specific humidity of the air

λv: latent heat of vaporization

Both equations have been substituted into the balance equation.

$$dq = h_c \cdot a \cdot dV \cdot (T' - T) + k \cdot (x_s - x) \cdot a \cdot dV \cdot \lambda_v \quad (21)$$

In turn, the mass transfer coefficient (k) can be approximated as hc/Cpw, therefore:

$$h_c = k \cdot C_{pw} \quad (22)$$

$$dq = k \cdot C_{pw} \cdot a \cdot dV \cdot (T' - T) + k \cdot (x_s - x) \cdot a \cdot dV \cdot \lambda_v \quad (23)$$

Factoring the equation above:

$$dq = k \cdot a \cdot dV \cdot (T' \cdot C_{pw} - T \cdot C_{pw}) + k \cdot a \cdot dV \cdot (x_s.\lambda_v - x \cdot \lambda_v) \quad (24)$$

The enthalpy of air has been defined as:

$$h = C_{pw} \cdot T + x \cdot \lambda_v \quad (25)$$

Substituting the air enthalpy equation:

$$dq = k \cdot a \cdot dV \cdot (h_S - h) = L \cdot C_{pw} \cdot dt = G \cdot dh \quad (26)$$

Equating each part of the above equation:

$$\frac{dq}{(h_S - h)} = k \cdot a \cdot dV \quad (27)$$

$$\frac{dt}{(h_S - h)} = \frac{k \cdot a}{L \cdot C_{pw}} \cdot dV \quad (28)$$

$$\frac{dh}{(h_S - h)} = \frac{k \cdot a}{G} \cdot dV \quad (29)$$

Equation 29 corresponds to the Merkel equation, which is a fundamental equation for the calculation used in cooling towers.

$$\int_{h_0}^{h_s} \frac{dh}{(h_S - h)} = \frac{k \cdot a}{G} \cdot \int_0^V dV \quad (30)$$

Integrating the above equation:

$$\int_{h_0}^{h_s} \frac{dh}{(h_S - h)} = \frac{k \cdot a}{G} \cdot V \quad (31)$$

V represents the volume of the fill, which in turn can be defined as area times height. Isolating the fill height:

$$z = \frac{G}{k \cdot a \cdot A} \cdot \int_{h_0}^{h_s} \frac{dh}{(h_S - h)} \quad (32)$$

Bibliographically, this expression is known as the height of transfer per number of transfer unit:

$$HTU = \frac{G}{k \cdot a \cdot A} \quad (33)$$

$$NTU = \int_{h_0}^{h_s} \frac{dh}{(h_S - h)} \quad (34)$$

$$z = HTU \cdot NTU \quad (35)$$

The parameter HTU will be calculated in the fill section.

To determine NTU, the integral has been solved (see table 2.4). A step size of 0.1 ºC has been used to increase result precision. NTU corresponds to the area between the equilibrium curve and the operating line, which is known as the "driving force" (see figure 2.5).

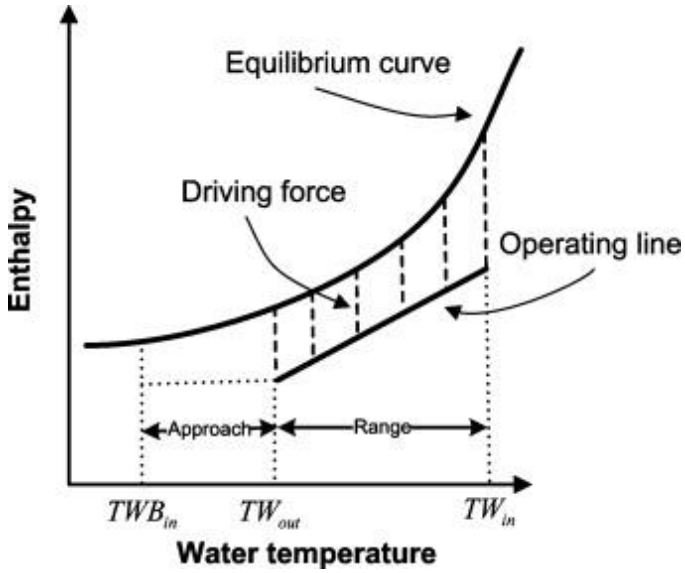


Figure 2.5. NTU graph definition.

Table 2.4. NTU calculation.

T (ºC)	h* (kJ/kg)	h (kJ/kg)	h*-h	1/ h*-h	Δ h	Average	Average· Δ h
26.0	80.1	60.6		19.5	5.12E-02		
26.1	80.6	61.3	0.7	19.3	5.18E-02	5.15E-02	3.36E-02
26.2	81.0	61.9	0.7	19.1	5.24E-02	5.21E-02	3.39E-02
26.3	81.4	62.6	0.7	18.9	5.29E-02	5.27E-02	3.43E-02
26.4	81.9	63.2	0.7	18.7	5.35E-02	5.32E-02	3.47E-02
26.5	82.3	63.9	0.7	18.5	5.41E-02	5.38E-02	3.51E-02
26.6	82.8	64.5	0.7	18.3	5.47E-02	5.44E-02	3.55E-02
26.7	83.2	65.2	0.7	18.1	5.53E-02	5.50E-02	3.58E-02
26.8	83.7	65.8	0.7	17.9	5.59E-02	5.56E-02	3.62E-02
26.9	84.2	66.5	0.7	17.7	5.65E-02	5.62E-02	3.66E-02
27.0	84.6	67.1	0.7	17.5	5.72E-02	5.68E-02	3.70E-02
27.1	85.1	67.8	0.7	17.3	5.78E-02	5.75E-02	3.74E-02
27.2	85.5	68.4	0.7	17.1	5.84E-02	5.81E-02	3.79E-02
27.3	86.0	69.1	0.7	16.9	5.91E-02	5.87E-02	3.83E-02
27.4	86.5	69.7	0.7	16.7	5.97E-02	5.94E-02	3.87E-02
27.5	86.9	70.4	0.7	16.6	6.04E-02	6.01E-02	3.91E-02
27.6	87.4	71.0	0.7	16.4	6.10E-02	6.07E-02	3.96E-02
27.7	87.9	71.7	0.7	16.2	6.17E-02	6.14E-02	4.00E-02
27.8	88.4	72.3	0.7	16.0	6.24E-02	6.21E-02	4.04E-02
27.9	88.8	73.0	0.7	15.8	6.31E-02	6.28E-02	4.09E-02
28.0	89.3	73.6	0.7	15.7	6.38E-02	6.34E-02	4.13E-02
28.1	89.8	74.3	0.7	15.5	6.45E-02	6.41E-02	4.18E-02
28.2	90.3	74.9	0.7	15.3	6.52E-02	6.49E-02	4.23E-02
28.3	90.8	75.6	0.7	15.2	6.59E-02	6.56E-02	4.27E-02
28.4	91.2	76.2	0.7	15.0	6.67E-02	6.63E-02	4.32E-02
28.5	91.7	76.9	0.7	14.8	6.74E-02	6.70E-02	4.37E-02
28.6	92.2	77.5	0.7	14.7	6.81E-02	6.78E-02	4.42E-02
28.7	92.7	78.2	0.7	14.5	6.89E-02	6.85E-02	4.46E-02
28.8	93.2	78.9	0.7	14.4	6.96E-02	6.92E-02	4.51E-02
28.9	93.7	79.5	0.7	14.2	7.04E-02	7.00E-02	4.56E-02
29.0	94.2	80.2	0.7	14.1	7.11E-02	7.08E-02	4.61E-02
29.1	94.7	80.8	0.7	13.9	7.19E-02	7.15E-02	4.66E-02

29.2	95.2	81.5	0.7	13.8	7.27E-02	7.23E-02	4.71E-02
29.3	95.7	82.1	0.7	13.6	7.35E-02	7.31E-02	4.76E-02
29.4	96.2	82.8	0.7	13.5	7.43E-02	7.39E-02	4.81E-02
29.5	96.7	83.4	0.7	13.3	7.51E-02	7.47E-02	4.87E-02
29.6	97.2	84.1	0.7	13.2	7.59E-02	7.55E-02	4.92E-02
29.7	97.8	84.7	0.7	13.0	7.67E-02	7.63E-02	4.97E-02
29.8	98.3	85.4	0.7	12.9	7.75E-02	7.71E-02	5.02E-02
29.9	98.8	86.0	0.7	12.8	7.83E-02	7.79E-02	5.08E-02
30.0	99.3	86.7	0.7	12.6	7.91E-02	7.87E-02	5.13E-02
30.1	99.8	87.3	0.7	12.5	7.99E-02	7.95E-02	5.18E-02
30.2	100.4	88.0	0.7	12.4	8.07E-02	8.03E-02	5.23E-02
30.3	100.9	88.6	0.7	12.3	8.16E-02	8.12E-02	5.29E-02
30.4	101.4	89.3	0.7	12.1	8.24E-02	8.20E-02	5.34E-02
30.5	101.9	89.9	0.7	12.0	8.32E-02	8.28E-02	5.40E-02
30.6	102.5	90.6	0.7	11.9	8.41E-02	8.36E-02	5.45E-02
30.7	103.0	91.2	0.7	11.8	8.49E-02	8.45E-02	5.50E-02
30.8	103.6	91.9	0.7	11.7	8.57E-02	8.53E-02	5.56E-02
30.9	104.1	92.5	0.7	11.6	8.66E-02	8.61E-02	5.61E-02
31.0	104.6	93.2	0.7	11.4	8.74E-02	8.70E-02	5.67E-02
31.1	105.2	93.8	0.7	11.3	8.82E-02	8.78E-02	5.72E-02
31.2	105.7	94.5	0.7	11.2	8.90E-02	8.86E-02	5.78E-02
31.3	106.3	95.1	0.7	11.1	8.99E-02	8.95E-02	5.83E-02
31.4	106.8	95.8	0.7	11.0	9.07E-02	9.03E-02	5.88E-02
31.5	107.4	96.4	0.7	10.9	9.15E-02	9.11E-02	5.94E-02
31.6	107.9	97.1	0.7	10.8	9.23E-02	9.19E-02	5.99E-02
31.7	108.5	97.7	0.7	10.7	9.31E-02	9.27E-02	6.04E-02
31.8	109.0	98.4	0.7	10.6	9.40E-02	9.35E-02	6.10E-02
31.9	109.6	99.1	0.7	10.6	9.48E-02	9.44E-02	6.15E-02
32.0	110.2	99.7	0.7	10.5	9.55E-02	9.51E-02	6.20E-02
						NTU	**2.814**

The value of the transfer unit number obtained is 2.814.

2.1.9 Water flow balance

Once the L/G ratio is known, the water flow balance can be performed.

The rate of the air mass flow circulating in the tower is (assuming water density is 1,000 kg/m³):

$$L = \frac{2{,}500\frac{m^3}{h} \cdot 1{,}000\frac{kg\ water}{m^3}}{3{,}600\ s} = 694.4\,\frac{kg\ water}{s} \quad (36)$$

$$G = \frac{694.4\frac{kg\ water}{s}}{1.559} = 445.6\,\frac{kg\ dry\ air}{s} \quad (37)$$

And with the dry air density, the air flow rate becomes:

$$G = \frac{445.6\frac{kg\ da}{s}}{1.1581\frac{kg\ da}{m^3}} = 384.7\,\frac{m^3}{s} \quad (38)$$

The amount of evaporated water can also be calculated:

$$m_{evaporate\ water} = G \cdot (W1 - W2) \quad (39)$$

$$m_{evaporate\ water} = 445.6 \cdot (0.0272 - 0.0139) = 5.93\,\frac{kg\ water}{s} \quad (40)$$

Another characteristic value used for cooling towers is to calculate the cycles of concentration using equation 41.

$$C = \frac{E+B+D}{B+D} \quad (41)$$

Where:

E is the evaporation rate, B is the blowdown rate, and D is the drift rate.

A value of 4 concentration cycles has been established, as this value typically falls within the range of 3-8.

Evaporation losses represent the amount of water evaporated. The theoretical evaporation amount is 1.8 m³ for every 1,000,000 kCal of rejected heat.

$$E = 0.0085 \cdot 1{,}8 \cdot L \cdot (Tw_{in} - Tw_{out}) \quad (42)$$

$$E = 0.0085 \cdot 1.8 \cdot 2{,}500 \cdot (32 - 26) = 22.95\,\frac{m^3}{h} \quad (43)$$

Drift losses depend on the design of the droplet eliminators. Most modern eliminators exhibit a drift loss efficiency lower than 0.01% of the recirculating flow rate:

$$D = L \cdot 0.01\% \quad (44)$$

$$D = 2{,}500 \cdot 0.01\% = 0.25\,\frac{m^3}{h} \quad (45)$$

Blowdown flow rate is the rate at which water is extracted to maintain the appropriate concentration of salts in the system. It has been obtained using equation 41.

$$B = \frac{E}{C-1} \quad (46)$$

$$B = \frac{22.95}{4-1} = 7.65\ \frac{m^3}{h} \quad (47)$$

Make-up flow rate is the amount of water that needs to be replenished in the system to initiate a new cycle:

$$M = E + B + D \quad (48)$$

$$M = 22.95 + 7.65 + 0.25 = 30.85\,\frac{m^3}{h} \quad (49)$$

2.2 Sizing of the cooling tower

2.2.1 Cooling tower area

Firstly, the area of the cooling tower is calculated. To obtain this value, the specific water flow rate i.e., total flow rate divided by the water dispersion area, must be defined. Typically, values between 12 and 18 m³/h/m² are considered. A design flow rate of 15 m³/h/m² has been chosen.

Based on a 20% oversizing, the cooling tower area will be:

$$A = \frac{Q_{cooled}}{Q_{design}} \cdot 1.20 \tag{50}$$

$$A = \frac{2{,}500}{15} \cdot 1.20 = 200\ m^2 \tag{51}$$

It has been determined that there will be 2 cells and the surface area of each cell will be:

$$A_{cell} = \frac{A}{Nº\ cells} \tag{52}$$

$$A_{cell} = \frac{200}{2} = 100\ m^2 \tag{53}$$

Assuming each cell has a width of 10 m, the length of each cell will be:

$$L_{cell} = \frac{A_{cell}}{W} \tag{54}$$

$$L_{cell} = \frac{100}{10} = 10.0\ m \tag{55}$$

2.2.2 Air inlet height

Initially, to determine the total height of the cooling tower, the inlet air height has been calculated.

The equation used to determine the air inlet height is:

$$H_{inlet\ aire} = \frac{G\left(\frac{m^3}{s}\right)}{v_{air}\left(\frac{m}{s}\right) \cdot nº entries \cdot L \cdot nº cells} \tag{56}$$

Where:

G is the volumetric flow rate of dry air.

V_{air} is the recommended velocity of entry air, 5 m/s.

L is 10m, as calculated previously.

Nº of entries corresponds to the number of entries per cell, set to 1 according to the manufacturer's criteria.

Nº of cells = 2.

The air inlet height will be:

$$H_{inlet\ air} = \frac{384.7}{5 \cdot 1 \cdot 10 \cdot 2} = 3.8\ m \tag{57}$$

2.2.3 Fill (Heat transfer)

Previously, for the NTU calculation, the equation 35 has been defined.

Typically, the fill height (z) falls within the range of 1.5 – 3 m. Assuming a value of 2 m, the height of transfer will be:

$$HTU = \frac{2}{2.828} = 0.71\ m \tag{58}$$

2.2.4 Water distribution system

The distribution system collects water from the collector, which has a diameter of 0.5 m. With this information, the inlet water velocity has been determined.

$$v_{in\ air} = \frac{\frac{L}{nº\ cells}}{A_{collector}} \tag{59}$$

The collector area has been defined as:

$$A_{collector} = \pi \cdot \left(\frac{D}{2}\right)^2 \tag{60}$$

$$v_{in\ air} = \frac{\frac{2{,}500}{2}}{\pi \cdot \left(\frac{0.5}{2}\right)^2} = 6{,}366.2\frac{m}{h} = 1.77\frac{m}{s} \tag{61}$$

2.2.5 Cold water basin

To size the tower basin, the number of cells must be considered, and an additional 1 meter should be considered on both sides of the larger dimension. A height of 1.5 meters has been assumed. The volume of the basin will be:

$$V_{basin} = (10 + 1 + 1) \cdot 10 \cdot 1.5 \cdot 2\ cells = 360\ m^3 \tag{62}$$

2.2.6 Fan

To size the fans of the cooling tower, the inlet air flow rate has been calculated. Each cell has a fan, therefore the air flow rate per cell will be:

$$G\ = \frac{445.5\frac{kg}{s}}{1.1581\frac{kg}{m^3}} = 384.7\frac{m^3}{s} \tag{63}$$

$$G\ = \frac{384.7\frac{m^3}{s}}{2} = 192.4\frac{m^3}{s} \tag{64}$$

3 Chemical treatment

3.1 Key Performance Indicators (KPIs)

These are parameters in the cooling system identified as indicators of the efficiency of the chemical treatment. These parameters provide information about the potential need for adjustments to work within the specifications without compromising the condition of the circuit.

Assuming that the treatment program has been designed to protect the system against corrosion, scaling, and bacterial growth, the following KPIs have been established:

A. Corrosion

- Soluble iron/turbidity: The presence of soluble iron in the system correlates with potential corrosion in the circuit, as iron is a byproduct of corrosion/erosion. Turbidity indicates the level of iron in the water and can also detect microbiological problems, circuit contaminations, or salt precipitation.

  Table 3.1. Soluble iron and turbidity specification values.

	Specification value
Iron value	≤ 0.5 ppm
Turbidity	< 15 NTU*

* The turbidity specification value, in NTU, is regulated by Royal Decree 487/2022 for Legionellosis Prevention, and therefore, these recommendations are followed.

- Corrosion rate for Ac/Cu: Online monitoring of corrosion rate through installed probe.

B. Bacterial growth

- Dip-slides: Weekly microbiological control has been performed using the dip-slide technique to quantify the presence of aerobic bacteria.

  Table 3.2. Bacterial growth specification values.

	Control range
Microbiological count, aerobic bacteria	< 10,000 CFU/ml
Legionella Pneumophilia	<50 CFU/L

3.2 Key Control Indicators (KCIs)

The variability of the following parameters can put significant stress on the system; therefore, their monitoring is essential to ensure that they remain within the established optimal ranges. If reference limits are exceeded, corrective actions must be taken to restore the variable to control levels.

A. pH.
The pH of the cooling water is a measure of the acid-base balance and is one of the most important factors in the treatment program for cooling systems. Based on the pH scale values, water has been classified as shown in Table 3.3.

Table 3.3. Water character classification based on pH.

pH	Tendency
5.5 – 6.0	Very aggressive
6.0 – 7.0	Aggressive
7-0 – 7.5	Moderate
> 7.5	Easier to treat even compared at the same T[a]

Wide fluctuations in the pH values indicate a potential risk of corrosion due to acid-induced corrosion/incrustation caused by minerals. Since mineral concentration and alkalinity increases due to the evaporation process, the addition of acid is often required to maintain the pH within the recommended control range.

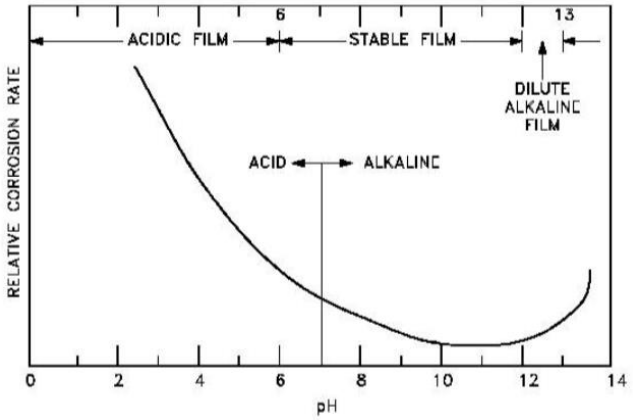


Figure 3.1. Corrosion/incrustation tendencies in relation to pH variations.

Significantly high or low pH levels can quickly lead to significant problems in system efficiency and even increased operating costs.
pH control has been carried out using 2 online analysers and maintain a control range between 7.4-7.6 units. The control system differentiates the higher pH value to control sulfuric acid dosing, and the lower pH value favours the microbiological strategy. It works at a pH value where the dissociation of NaClO favours hypochlorous acid (HOCl-, biocidal action).

B. Conductivity/ Hardness.
This parameter refers to the concentration of dissolved salts in the water. Higher concentration causes higher conductivity, and poor adjustment of this KCI can eventually lead to scaling, corrosion, reduced heat transfer, and energy loss.
The optimal control range of conductivity/hardness is maintained by adjusting the blowdown flow rate; for example, when concentrations are too low, the blowdown is reduced.

C. Chlorine residual.
Hypochlorite is the most commonly used oxidizing biocide for microbiological control. However, poor adjustment of chlorine or other oxidizing agents may introduce new issues in the system, possibly more counterproductive than the bacteria themselves. For example, a biocide deficit can lead to incomplete disinfection and significant microbiological slime problems. Conversely, an excess

of oxidizing agent can trigger corrosion problems and interfere with the chemical behaviour of some water treatment programs.
The amount of oxidizing biocide in the system is generally controlled by adjusting the amount of chemical injection and based on the values measured by the online analyser.
Chlorine addition is the most important parameter for microbiological control in a system. To prevent microbial growth in the system, and in accordance with RD 487/2022, it is recommended that chlorine residual values be maintained between 0.5-0.9 ppm.

D. Concentration cycles.
The number of cycles depends on the quality of the makeup water and whether calcium, chlorides, or conductivity is kept within the limits in the recirculating water. Theoretically, evaporation in the cooling tower is pure water, so all dissolved ions will become concentrated in the system. When the concentration of ions exceeds solubility in water, there is a significant risk of scaling, corrosion, deposition, and inefficient system operation.
Concentration cycles must be controlled and stay within a range that represents low stress. In terms of scaling, inhibitors can help prevent this phenomenon. The goal of this method is to optimize concentration cycles so as to minimize water consumption, optimize chemical treatment required, and, at the same time, keep scaling under control.

E. Residual chemicals.
Monitoring the residual chemicals inhibitors for corrosion and scaling is necessary to track the product concentration and the effectiveness of the chemical treatment.

3.3 Monitoring of water quality control variables

In order to ensure that the treatment achieves its objectives of preventing corrosion, scaling, and microbiological fouling, compliance with the following limit values established in the different control parameters and variables must be ensured.

Table 3.3. Optimal control ranges for different KCIs.

Parameter	Limit value	Actions
pH	7.4 – 7.6	<u>If pH is at 7.5 ± 0.2 or 7.0 – 7.2 / 7.7 – 7.9</u> 1. Verify redundant pH meter readings. 2. In case of discrepancy between values, notify the analyser team for calibration. 3. Compare measurements between coincident analysers and values out of range ➔ check sulfuric acid dosing system. Additionally, the decrease in the acid tank level and consumption will be checked. <u>If pH < 7 or pH > 8.2, critical system</u> If pH < 7.0: **Immediately stop acid dosing.** Open the blowdown valve to renew water as quickly as the makeup water allows. If pH > 8.2: Open the blowdown valve to reduce calcium hardness to 900 ppm and 3 cycles of concentration. Verify the acid dosing for any obstruction
Chlorine, Cl_2 (ppm)	0.5 – 0.9	If > 0.9 or < 0.5 1. Compare online analyser value with field analytical result (chlorine measurement in the field). 2. In case of discrepancy between values, notify the analyser team for calibration. 3. Compare measurements between coincident analysers and values out of range ➔ check sodium hypochlorite dosing system. If intervention of the dosing equipment is required, stop sodium hypochlorite dosing. If it takes more than 1 day, perform shocks of the non-oxidizing biocide.
Calcium hardness, $CaCO_3$ (ppm)	< 1300	If > open blowdown valve, if < close blowdown valve. If the blowdown valve cannot be opened due to any operational problem, adjust the pH value to 7.3 and increase the dispersant setpoint. Additionally, increase the corrosion inhibitor dosage.
Soluble iron, Fe (ppm)	≤ 0.5	If > 0.5 1. Verify the operation of the side stream filter if the time between backwashes has decreased due to possible

		loss of efficiency. 2. If a malfunction of the filter is confirmed, readjust the chemical treatment dosage. 3. If the filter is operating correctly, check the pH value in case it has dropped below 7 units. 4. Check if the NaClO dosing is within range to ensure that the increase in iron is not due to overdosing.
Turbidity (NTU)	15	If > 15 1. Verify the operation of the side stream filter if the time between backwashes has decreased due to possible loss of efficiency. 2. If a malfunction of the filter is confirmed, readjust the chemical treatment dosage. 3. If the filter is operating correctly, verify the microbiological strategy in case the increase in turbidity is due to the formation of microbiological flocs.
Bacteria (UFC/ml)	10^4	Adjust Cl_2 dosage and range.
Legionella	< 50	Follow RD recommendations.
Corrosion (Mild Steel/Cooper) (mpy)	<1 / <0.1	If > review the corrosion inhibition program. 1. First, check if corrosion is localized or general. 2. Check chlorine values in the system to determine if there have been periods with high chlorine residuals that may have caused an increase in corrosion rates. 3. Review the operation of the side stream filter as the impact of solids on under-deposit corrosion is known. 4. Check the dosing of chemical additives in case values have been below the recommended limit.

4 Installation maintenance

The Royal Decree 487/2022 establishes regulations and standards to prevent and control the spread of Legionella in cooling water systems. Within its directives, various aspects are addressed, from design and operation to maintenance and cleaning of cooling towers and evaporative condensers. The decree emphasizes the importance of risk assessment, regular inspections, water quality monitoring, and the implementation of appropriate measures to safeguard public health. Below, an excerpt of the maintenance requirements applicable to cooling towers has been included.

4.1 Operating criteria

In a cooling water system, temperature conditions typically cannot be modified as they depend on the system's design characteristics and ambient conditions. However, when external requirements allow, the system can provide water cooling without activating the fans. This results in energy savings and reduces the risk of Legionella dispersion, as not using fans prevents the propelling of air laden with water droplets to the outside.

Automated systems can be implemented to gradually increase the air flow based on water temperature. Theoretically, variable-speed fans could be used, although in practice, due to economic reasons, these measures are not commonly adopted.

When the installation operates intermittently and remains idle for periods shorter than a month, water with a biocide will be recirculated daily. If possible, this recirculation can occur with the fans turned off to ensure proper biocide distribution.

4.2 Inspection

During inspections of the installation, its proper functioning, conservation, and cleanliness will be checked. The inspection of all parts of the installation to verify their good operation will follow the periodicity outlined in Table 4.1.

Table 4.1. Periodicity inspections.

Installation elements		Periodicity
Tray: It must be ensured that there is no general dirt, algae, sludge, corrosion, or deposits. The water should be clean.		Monthly
Fill: Absence of debris, algae, sludge, etc., should be verified. Additionally, its integrity should be checked.		Biannually
Pipes: To facilitate inspection, a detachable point should be available to review the interior surfaces, at least at one point, as a representation of the entire piping system.		Biannually
Drift eliminator: It must not have remnants of dirt, algae, or sludge, and should be correctly positioned on the support frame. Due to its importance, its proper installation and integrity will be ensured after each cleaning and disinfection.		Minimum Annually (recommended biannually)
Filters and other water treatment equipment: Verify that they are properly installed and in good hygienic condition.	Supply filters	Biannually
	Recirculation filters	Monthly
	Other equipment	Monthly
Exterior of the unit: It should not suffer from corrosion and should exhibit structural integrity.		Annually

In general, the condition and cleanliness will be examined to identify the presence of sediment, scale, corrosion products, sludge, algae, or any other factors that may affect or potentially affect the proper functioning of the installation. If any deteriorated components are found, repair or replacement will be carried out. Additionally, the physicochemical and microbiological quality of the water in the system will be examined.

Table 4.2. Water quality control parameters.

Parameter	Analysis method	Periodicity
Chlorine or biocide level	Active ingredient	Daily
Temperature	Direct reading thermometer	Monthly
pH	Direct reading pH meter	
Conductivity	Direct reading electrochemical probe	
Turbidity	Turbidimeter	
Total iron	Spectrophotometer	
Total aerobic count	According to ISO 6222 standard. Water quality. Enumeration of cultivable microorganisms. Colony count by planting on nutrient agar medium. *	Monthly
Legionella sp	According to ISO 11731. Standard. Part 1. Water quality. Detection and enumeration of Legionella.	Minimum: quarterly. Approximately 15 days after any cleaning and disinfection.

* The ISO 6222 standard specifies two temperature levels. For cooling towers, analysis at 36ºC is sufficient as it is closest to the operating range of the installation.

Additional parameters that are considered useful for determining water quality or evaluating the effectiveness of the water treatment maintenance program will be included if necessary.

All determinations must be conducted by knowledgeable personnel using systems and instruments subject to quality control, proper calibrations, and accurate handling.

4.3 Sampling protocol

The sampling point in the installation is a crucial factor in ensuring the representativeness of the sample. The following guidelines should be considered for each parameter:

Table 4.3. Sampling procedures.

Parameter	Sampling protocol
Chlorine or biocide level	Sample should represent the biocide concentration in the circuit. The sampling point should be away from the make-up water and the biocide injection point. - If the biocide is added at a point outside the main tank, the sample will be collected from the main basin. - If the biocide is added in the main basin, the sample will be collected from the tower return. The dosing regimen of biocides must be considered. When a minimum residual concentration is required due to the biocide type, the sample should be taken shortly before addition. For shock additions, such as non-oxidizing biocides where maintaining a minimum residual concentration is not necessary, the sampling should be performed a significant time after addition. The time interval will depend on the volume of water in the basin and the recirculation flow rate of the installation.
pH	Measured at the same point used for biocide analysis.
Temperature Total iron Conductivity Turbidity	Directly from the basin at a point far from the water inlet or from the return circuit, based on the installation characteristics or risk assessment. Consider the most unfavourable parameter value for the risk determination algorithm.
Total aerobic count	Samples should be collected in sterile containers with the appropriate neutralizer for the biocide used. A portion of the sample will be taken from the basin (away from the biocide addition point) and another portion from the return, forming a single sample for analysis.
Legionella sp	Samples should be collected in sterile containers with the appropriate neutralizer for the biocide used. A portion of the sample will be taken from the basin (away from the biocide addition point) and another portion from the return, forming a single sample for analysis. The total sample volume collected should be at least 1L. Measure water temperature, pH, and free chlorine content and record them in the sampling data.

It is important to note that these recommendations are general, and the sampling point will often depend on the design, installation characteristics, and other factors determined through risk assessment. Therefore, this aspect should be considered when conducting the risk assessment.

4.4 Cleaning and disinfection

During disinfection treatments, precautions must be taken to prevent risk situations for both the personnel performing the treatments and the users of the facilities.

For workers, the provisions of the Occupational Risk Prevention Law and its regulations will be followed. Personnel should have completed authorized courses for conducting hygienic-sanitary maintenance operations for the prevention and control of legionellosis, as stated in Order SCO 317/2003, February 7.

Three types of actions can be distinguished within the installation:

1. Routine cleaning and disinfection program
2. Shock cleaning and disinfection
3. Cleaning and disinfection in case of Outbreak

4.4.1 Cleaning and maintenance disinfection program

This program aligns with continuous water treatment programs specified in Article 8.1 of Royal Decree 487/2022 for installations with a higher likelihood of Legionella proliferation and dispersion. It can be carried out using chlorine, any other authorized biocide, or proven effective physical or physicochemical systems.

Biocides are usually supplied in liquid or solid form and are continuously dosed. Continuous dosing involves using dosing pumps for liquids or continuous dilution of solid products to ensure automatic addition without manual intervention, providing a minimum residual biocide concentration as specified by the manufacturer. This residual concentration should be effective for Legionella disinfection in water.

Dosing can be done through timed dosing pumps, proportional to the incoming water flow rate, or controlled by a biocide residual measurement probe. Manual periodic addition of biocide directly to the basin is not allowed.

Annex 4 of Royal Decree 487/2022 requires determining the level of biocide or chlorine used in daily disinfection. Some biocides, like non-oxidizing ones, act as a one-time shock disinfection upon addition, depleting within a few hours. Periodic additions can be made to ensure continuous water disinfection. This implies that the residual concentration will vary, so the detected level may differ depending on when the water sample is taken for analysis.

To control the proper dosing of such biocides, appropriate record-keeping systems, electronic or written, must be in place for daily biocide amounts added, in accordance with the manufacturer's and applicator's instructions.

4.4.2 Cleaning and disinfection shock

This corresponds to the annual preventive cleanings specified in Annex 4B General Procedure of Royal Decree 487/2022.

The annex includes a protocol for chlorine use. For other biocides, they must be specifically authorized for use in shock treatments, and the protocol used should be documented according to manufacturer and applicator instructions.

Consistent with the general principle of Royal Decree 487/2022 that disinfection without thorough cleaning is ineffective, the installation must be stopped, and physical dirt must be removed. In exceptional cases where stopping is impossible, a shock disinfection can be conducted following the protocol defined in Annex 4B of Royal Decree 487/2022 (for chlorine use) for equipment that cannot be shut down.

For the use of other biocides, they must be specifically authorized for use in Legionella treatments in that installation, and the protocol used should be documented according to manufacturer and applicator instructions. This protocol should account for higher concentrations and/or longer recirculation times (the duration of the shock biocide concentration) than those used in installations that can be stopped, to compensate for the lack of cleaning.

4.4.3 Cleaning and disinfection in case of outbreak

This corresponds to the cleanings specified in Annex 4C of Royal Decree 487/2022 Procedure in Case of Outbreak. In this case, only the use of chlorine as a biocide is authorized.

4.5 Assessment criteria for results

The monitoring section lists various parameters to measure along with their reference values and corrective actions that can be taken in case of deviations.

4.6 Troubleshooting associated with the installation

Occasionally, cases arise in cooling towers and evaporative condensers where Legionella sp persists even after shock treatments are performed upon its detection. In these cases, it's necessary to inspect the installation for underutilized pipeline sections, stagnant branches, sections located below the drainage point, or those that cannot be adequately drained for some reason.

Some installations have bypass pipeline sections that are only opened occasionally. These should be opened to ensure treatment of the internal water when circuit disinfection is carried out.

Likewise, clogged sprayers can create stagnant points in spray ducts. Some installations have backup equipment, often with an automatic alternate operation system. Disinfection must ensure that all these equipment and associated sections have been treated. In such cases, changing the active ingredient of the disinfectant to a different one from the continuous treatment can be helpful.

4.7 Description of records for the installations

Maintenance records should be kept in these installations, including:

- Annotated installation diagram describing water flows.
- Performed maintenance operations, including inspections of various parts of the system.
- Water analysis in the basin, including daily biocide records (added or residual) for installations that use them.
- Cleaning-disinfection certificates.
- Risk assessment results.

The content of the records and treatment certificates should conform to the specifications of Royal Decree 487/2022.

5 Data sheets

5.1 Cooling tower

PROJECT	TFM-xbalague	**SPECIFICATION SHEET**	Nº	1
		INDUCED DRAFT COOLING TOWER	SHEET Nº	1
COMPANY	N/A		DATE	sep.-23
FACTORY	N/A		PREPARED	Xènia Balagué
PLANT	Refinery		REVISED	-
			APROVED	-
ITEM	CT-7023		Nº UNITS	1
DESCRIPTION	Counterflow induced draft cooling tower			

OPERATING AND DESIGN CONDITIONS			**DESIGN (BY MANUFACTURER)**		
Circulating water flow rate	m3/h	2,500	Number of cells		2
Hot water temperature (inlet)	ºC	32	Cell dimensions	m	8x10x10
Cold water temperature (outlet)	ºC	26	Overall dimensions tower	m	12.5x23x10
Wet bulb temperature (inlet)	ºC	21	Inner dimensions basin	m	1.5x23x10.5
Dry bulb temperature (inlet)	ºC	25	Air inlet height	m	3.8
Ambient relative humidity	%	70	Total fill height	m	2.4
Altitude above sea level	m	0	Fan cylinder height	m	3.0
Prevailing wind direction	-	NE (40% time) SE (20%time)	Total tower height	m	8.0
			Cell cros-section	m2	100
Soil resistance	kg/cm2	-	Fill volume	m3	240
Avaiable space		-	Nº of water inlets per cell	-	1
Heat transfered	MW	15	Nominal diameter of water inlets	m	0.5
Type of pumps		Centrifuges	Nº of fans per cell	-	1
Pump orientation		Horizontals	Fan diameter	m	7.92
Nº of pumps		2+1	Airflow per fan	m3/s	192.4
Voltage/Phase/Cycle	<150 kW	-	Number of transfer units		2.814
	>150kW	-	Specific water flow rate	m3/h/m2	15
Access gateway to mechanical unit		yes	L/G value	-	1.559
Acces to the roof		yes	Drif losses	%	0.01
Permisible noise level on the ground		95dB at 1 m	Evaporation losses flow	m3/h	22.95
			Make-up flow	m3/h	30.85
			Blowdown flow	m3/h	7.65
Quality of make-up water		NOTE 1	Nº cycles concentration	-	4

CONSTRUCTION MATERIALS (BY THE MANUFACTURER)					
Structure		FRP	Type of fill		Laminar
Casing		RP	Fill material		PVC
Interior partitions		FRP	Fill support		FRP beams
Cover		FRP	Drift eliminators		PVC
Diffusers		PVC	System water distribution		FRP beams
Cold water basin		Concrete	Ducts		PVC
Supports		FRP	Sprinklers		PP
Access gateway to mechanical unit		FRP			

NOTES

1- Quality of make-up water. Water from the river Ebro will be used. The physico-chemical characteristics of this water are as follows:

pH	7.8-8	Chlorides	<300 ppm
Conductivity	<2000 microS/cm	Iron	<1 ppm
Temperature	Ambient	Turbidity	<5 NTU
Hardness calcium	300 ppm		

5.2 Fan

Fan Selection Data

Design conditions

Howden

Project name:	Master Industrial Engineering	**Description:**	Cooling Tower Design
Project ref:		**Customer name:**	Xenia Balague
Project file name:	C:\Users\xenia...\Fan Selection.hsp	**Howden ref:**	

Fan Data 7920DLF5:

Type:	7920DLF5 ◄
Diameter:	7920 mm ◄
Blades:	5 ◄
Blade angle:	5.0 °
Fan Static Efficiency:	70 %
Mass:	809 kg
Moment of inertia:	2078.4 kg.m²

Input data = ◄

Application Data:

Application:	Cooling Tower ◄
Draught:	Induced Draught ◄
Mounting orientation:	Vertical shaft; hub at inlet ◄
Inlet shape:	Bell, L=0.15D ◄
Duct height:	0 mm ◄
Tip clearance:	0.50 % ◄
Diffuser:	n.a. ◄
Obstacles:	
Inlet frontal area:	n.a. ◄
Inlet obstacle distance:	n.a. ◄
Outlet frontal area:	n.a. ◄
Outlet obstacle distance:	n.a. ◄
Crosswind:	0.0 m/s ◄
Resistance exponent:	2 ◄

n.a. = not applicable — Input data = ◄

Operating Conditions:

Airflow:	192.4 m³/s ◄		
Pressure correction:	0 % ◄		
Static pressure:	180.0 Pa ◄		
Correction:	0.0 Pa	Outlet obstacles:	0.0 Pa
Inlet shape:	0.0 Pa	Diffuser:	0.0 Pa
Inlet obstacles:	0.0 Pa	Crosswinds:	0.0 Pa
Inlet height:	0.0 Pa	Tip clearance pressure loss:	0.0 Pa
Fan Static Pressure:	180.0 Pa		
Fan speed:	123.3 rpm ◄		
Tip speed:	51.1 m/s		
Fan shaft power:	49.6 kW		
Fan shaft torque	3841 Nm		
Airflow margin:	18.5 % [1]	-100.0 [2]	
Pressure margin:	40.4 % [1]	68.4 % [2]	

1) according to API *2) at selected blade angle*

Air density:	1.174 kg/m³ ◄
Inlet temperature:	25.0 °C ◄
Axial thrust:	9171 N
Force loss of 1 / 2 blade(s):	24969 N / 40401 N
Imbalance (ISO 21940-11 G6.3):	56 N
Fan rotation frequency:	2.1 Hz
Fan operating natural freq:	7.1 Hz
Blade passing frequency:	10.3 Hz

n.a. = not applicable t.b.s. = to be specified — Input data = ◄

Acoustical Data: (impeller only)

Lw(A) fan:	99.4 dB(A)
Inlet shape:	0.0 dB(A)
Inlet obstacles:	0.0 dB(A)
Outlet obstacles:	0.0 dB(A)
Lw(A) fan total:	99.4 dB(A)

Tolerance on Lw(A) fan total ± 2 dB(A)

Lp(A) 1m beside outlet:	72.6 dB(A)
Lp(A) 1m above outlet at 45°:	75.6 dB(A)
Lp(A) 1m above outlet:	80.7 dB(A)
Lp(A) 1m below cooler:	77.4 dB(A)

Sound pressure levels for guidance only!

Howden Netherlands B.V. Haaksbergerstraat 67, 7554 PA Hengelo, The Netherlands, Tel: +31 (0)74 255 6000. Web: **www.howden.com**

Fan Selection Data

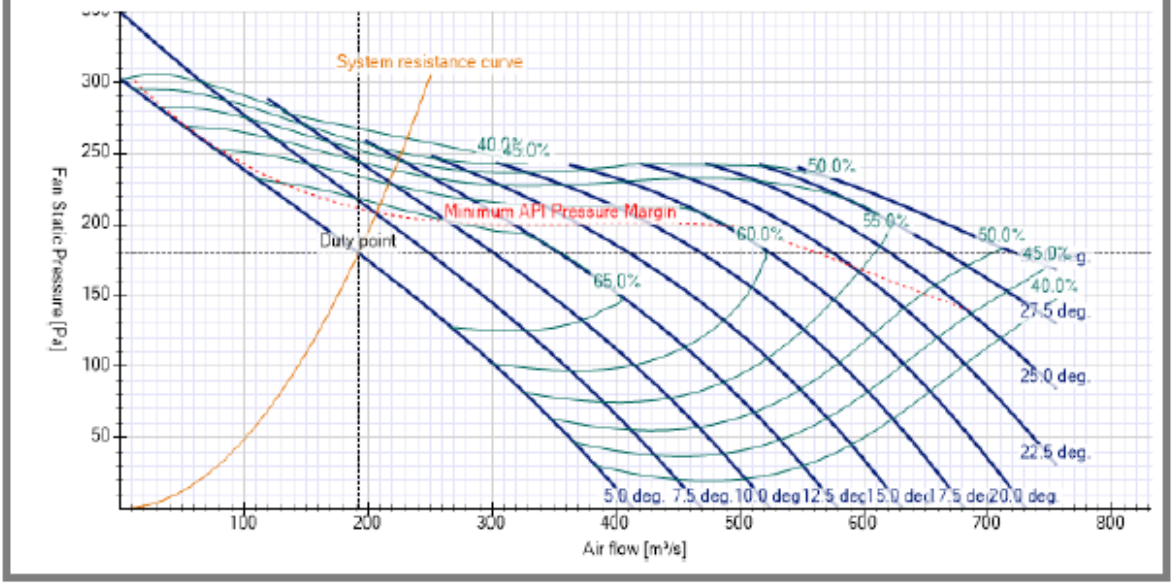
Design conditions

Howden

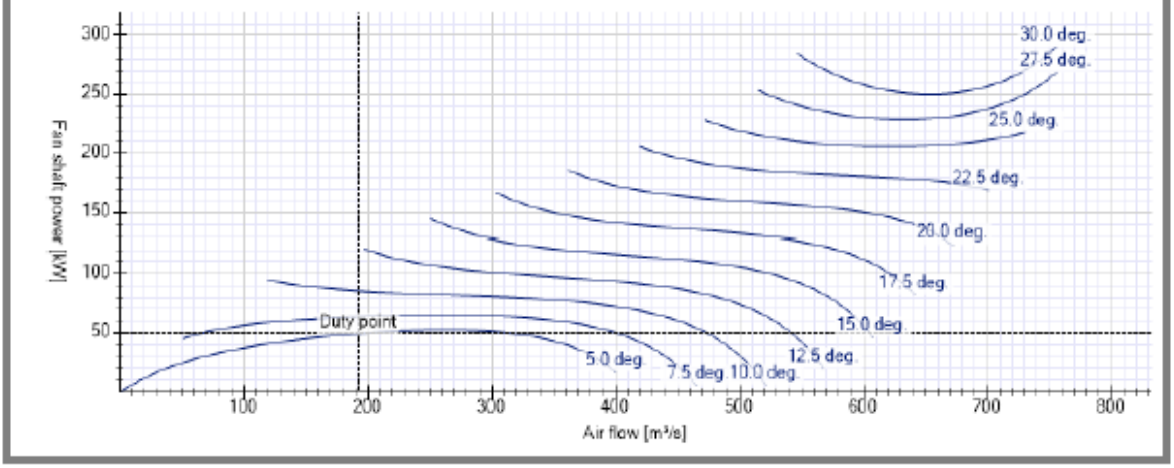
Project name:	Master Industrial Engineering	**Description:**	Cooling Tower Design
Project ref:		**Customer name:**	Xenia Balague
Project file name:	C:\Users\xenia...\Fan Selection.hsp	**Howden ref:**	

Fan type:	7920DLF5	**Fan speed:**	123.3 rpm
Fan diameter:	7920 mm	**Air density:**	1.174 kg/m³
Number of blades:	5	**Static efficiency:**	70 %
Blade angle:	5.0 °		

Performance Graph:



Fan Shaft Power Graph:



Acoustical Data (impeller only)

Design conditions

Howden

Project name:	Master Industrial Engineering	**Description:**	Cooling Tower Design
Project ref:		**Customer name:**	Xenia Balague
Project file name:	C:\Users\xenia...\Fan Selection.hsp	**Howden ref:**	

Fan type:	7920DLF5	**Obstacles:**	
Fan diameter:	7920 mm	Inlet frontal area:	n.a.
Number of blades:	5	Inlet obstacle distance:	n.a.
Fan speed:	123.3 rpm	Outlet frontal area:	n.a.
Inlet shape:	Bell, L=0.15D	Outlet obstacle distance:	n.a.
		Crosswind:	0.0 m/s

Summary

Sound power level

Lw(A) fan: 99.4 dB(A)

Inlet shape: 0.0 dB(A)
Inlet obstacles: 0.0 dB(A)
Outlet obstacles: 0.0 dB(A)

Lw(A) fan total: 99.4 dB(A)

Tolerance on Lw(A) fan total ± 2 dB(A)

Sound pressure levels

Lp(A) 1m beside outlet: 72.6 dB(A)
Lp(A) 1m above outlet at 45°: 75.6 dB(A)
Lp(A) 1m above outlet: 80.7 dB(A)
Lp(A) 1m below cooler: 77.4 dB(A)

Sound pressure levels for guidance only!

Total sound power level

f [Hz]	Lw fan total Linear [dB]	Lw(A) fan total A-weigthed [dB(A)]	Tolerance ±[dB]
63	103.0	76.8	5
125	101.5	85.4	3
250	99.5	90.9	2
500	96.5	93.3	2
1000	93.0	93.0	2
2000	91.5	92.7	2
4000	88.5	89.5	2
8000	84.5	83.4	2
Overall	107.1	99.4	2

Sound pressure levels

Position	1m beside outlet		1m above outlet at 45°		1m above outlet		1m below cooler	
f [Hz]	Lp Linear [dB]	Lp(A) A-weigthed [dB(A)]	Lp Linear [dB]	Lp(A) A-weigthed [dB(A)]	Lp Linear [dB]	Lp(A) A-weigthed [dB(A)]	Lp Linear [dB]	Lp(A) A-weigthed [dB(A)]
63	76.2	50.0	79.2	53.0	84.2	58.0	81.0	54.8
125	74.7	58.6	77.7	61.6	82.7	66.6	79.5	63.4
250	72.7	64.1	75.7	67.1	80.7	72.1	77.5	68.9
500	69.7	66.5	72.7	69.5	77.7	74.5	74.5	71.3
1000	66.2	66.2	69.2	69.2	74.2	74.2	71.0	71.0
2000	64.7	65.9	67.7	68.9	72.7	73.9	69.5	70.7
4000	61.7	62.7	64.7	65.7	69.7	70.7	66.5	67.5
8000	57.7	56.6	60.7	59.6	65.7	64.6	62.5	61.4
Overall	80.3	72.6	83.3	75.6	88.3	80.7	85.0	77.4

Both the directivity and the degree of damping of sound strongly depend on the frequency. However, in the spectra shown above, it is assumed that the deflected sound has the same frequency distribution as the sound radiated directly from the source.

Reference sound power level = 2 pW [2x10^(-12) Watt]
Reference sound pressure level = 10 µPa [10^(-5) Pa]

Fan Selection Data

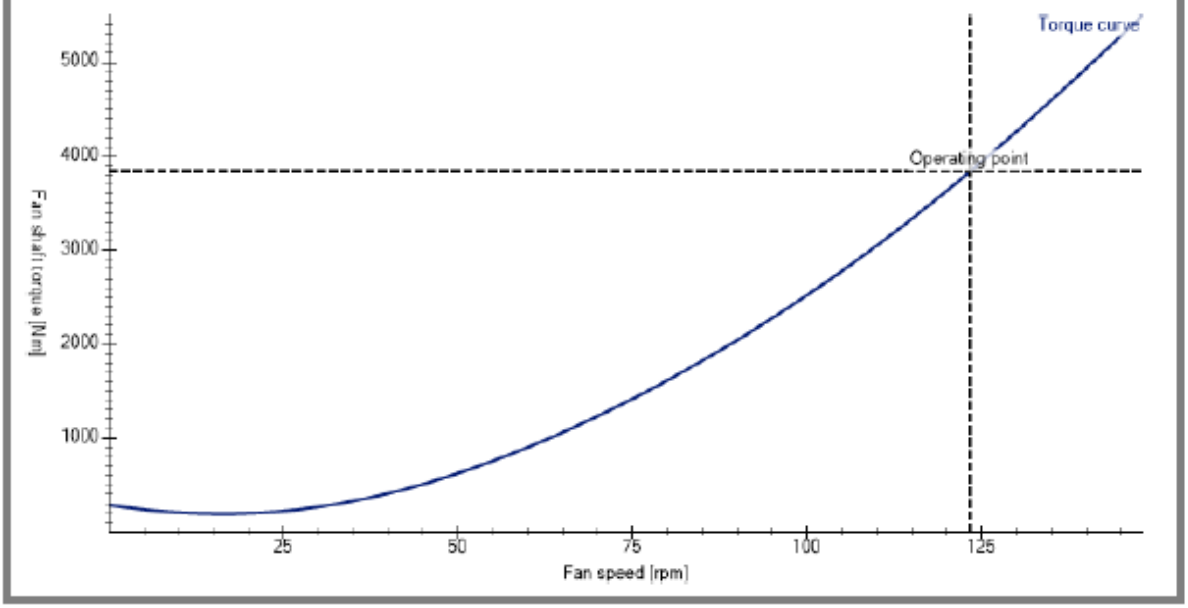
Design conditions

Howden

Project name:	Master Industrial Engineering	**Description:**	Cooling Tower Design
Project ref:		**Customer name:**	Xenia Balague
Project file name:	C:\Users\xenia...\Fan Selection.hsp	**Howden ref:**	

Fan type:	7920DLF5	**Fan speed:**	123.3 rpm
Fan diameter:	7920 mm	**Fan shaft power:**	49.6 kW
Number of blades:	5	**Fan shaft torque:**	3841 Nm

Torque curve:



Fan Selection Data

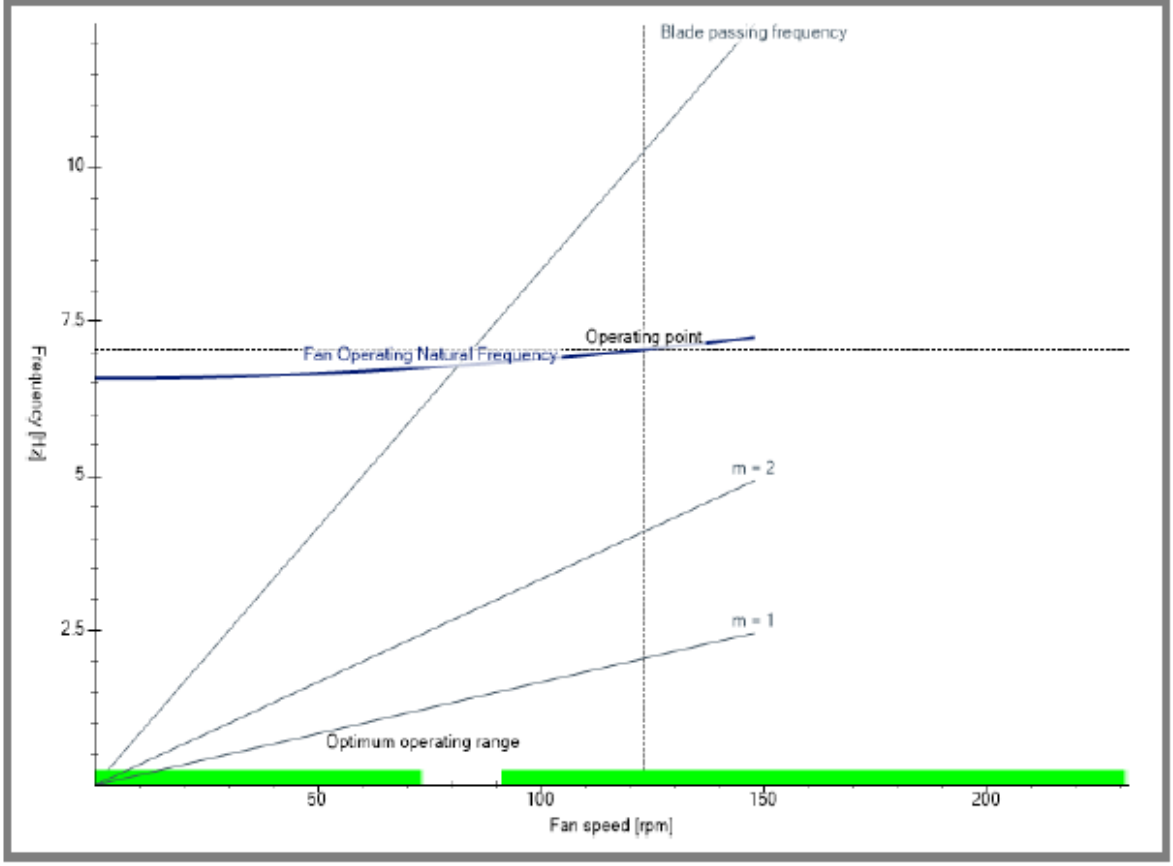
Design conditions

Howden

Project name:	Master Industrial Engineering	**Description:**	Cooling Tower Design
Project ref:		**Customer name:**	Xenia Balague
Project file name:	C:\Users\xenia...\Fan Selection.hsp	**Howden ref:**	

Fan type:	7920DLF5	**Fan rotating Frequency:**	2.1 Hz
Fan diameter:	7920 mm	**Blade operating natural freq:**	7.1 Hz
Number of blades:	5	**Blade passing frequency:**	10.3 Hz
Fan speed:	123.3 rpm		

Campbell Diagram:



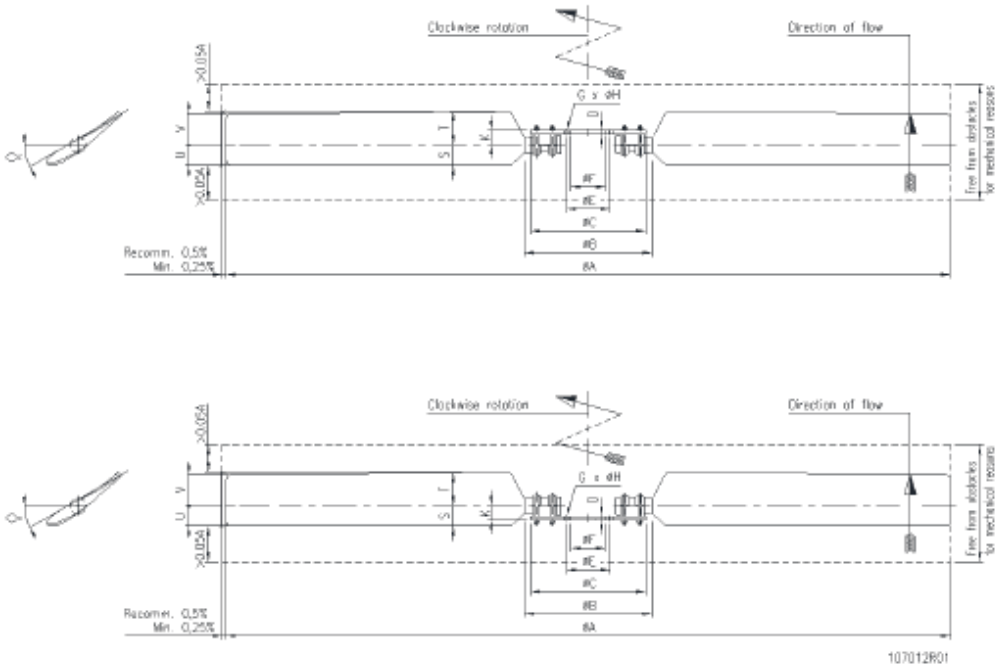
Dimension sheet

Design conditions

Howden

Project name:	Master Industrial Engineering	**Description:**	Cooling Tower Design
Project ref:		**Customer name:**	Xenia Balague
Project file name:	C:\Users\xenia...\Fan Selection.hsp	**Howden ref:**	

Dimension sheet 7920DLF5:



All sizes in mm

A	B	C	E	F	G*H	K	D	m [kg]	I [kg.m²]
7920	1050	1015	340	250	8*33	150	45	809	2078.4

Coupling flange (optional)	
Type	Bore
250D	Cylindrical, with key way
	Conical, suitable for split taper bushing(s): U1 (5.499 in)

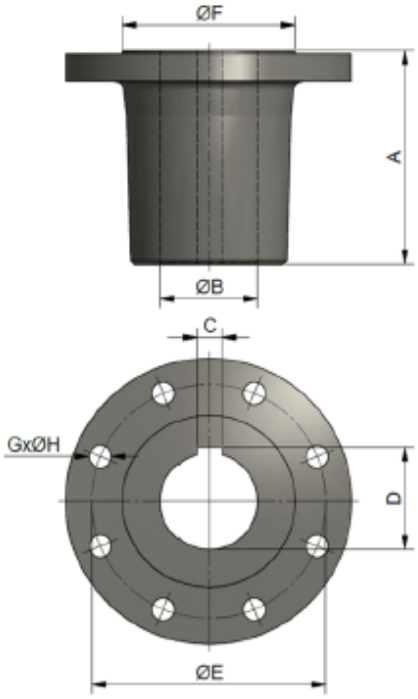
Blade angle data				
α [°]	S	T	U	V
5.0	78	174	75	128

Coupling flange

Design conditions

Project name:	Master Industrial Engineering	**Description:**	Cooling Tower Design
Project ref:		**Customer name:**	Xenia Balague
Project file name:	C:\Users\xenia...\Fan Selection.hsp	**Howden ref:**	

Coupling Flange Dimensions - Type 250D:

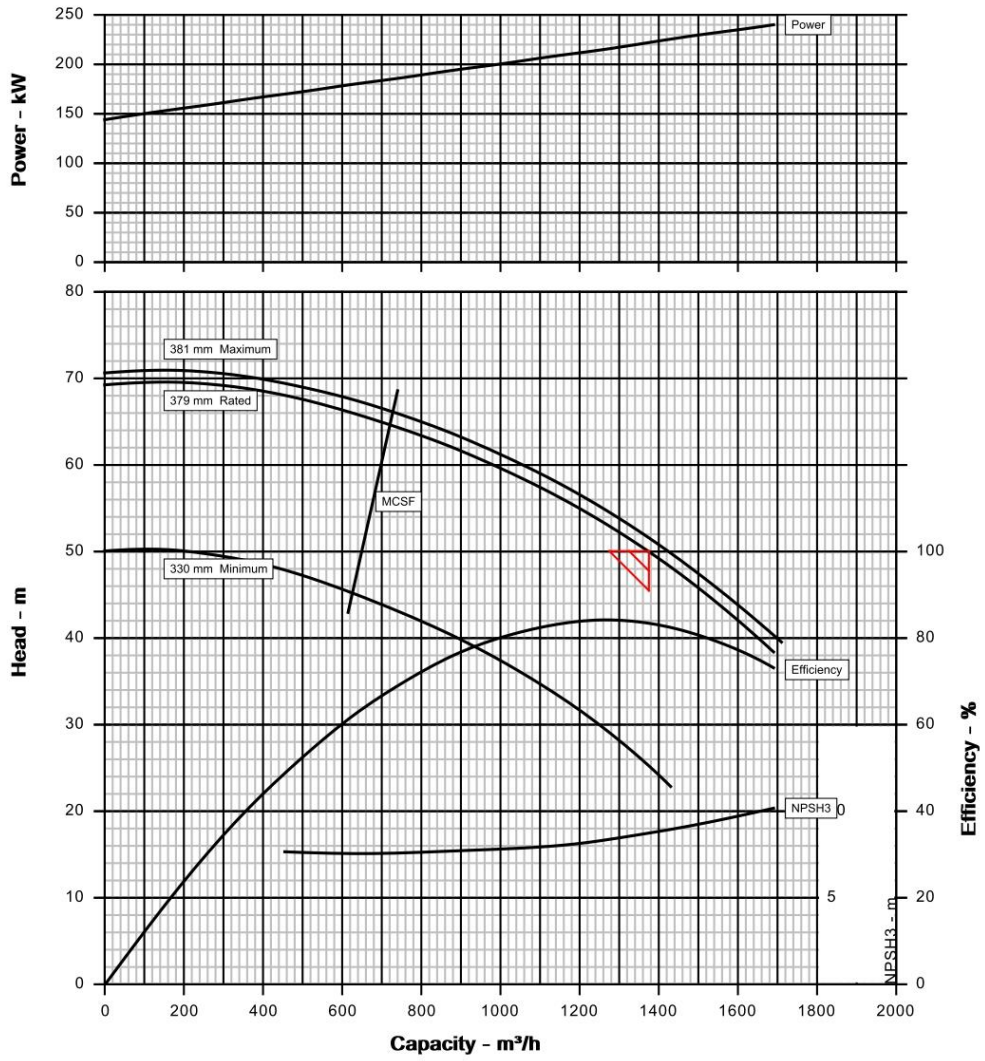


Dimension	Value
A	310.0 mm (Max)
Ø B (Tol. H7)	140.0 mm (Max)
C	36.0 mm
D	148.4 mm
Ø E	340
Ø F (Tol. H6)	250
G*H	8*33

5.3 Recirculating pump

FLOWSERVE		Pump size & type / Stages	: 3K10x8M-16H/15RVSM / 1
		Based on curve no.	: MIII8435V
		Impeller diameter	: 379 mm
Customer	: Xenia Balague	Capacity	: 1,375.0 m³/h
Item number	: -	Head	: 50.00 m
Service	: -	Density / Specific gravity	: - / 0.992
Flowserve reference	: 4574534422	Pump speed	: 1,780 rpm
Date	: August 1, 2023	Ns / Nss (per eye)	: 53 / 216 (SI)
		Test tolerance	: ANSI/HI 14.6 Grade 1B

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS; CAPACITY, HEAD, AND EFFICIENCY.



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FLOWSERVE

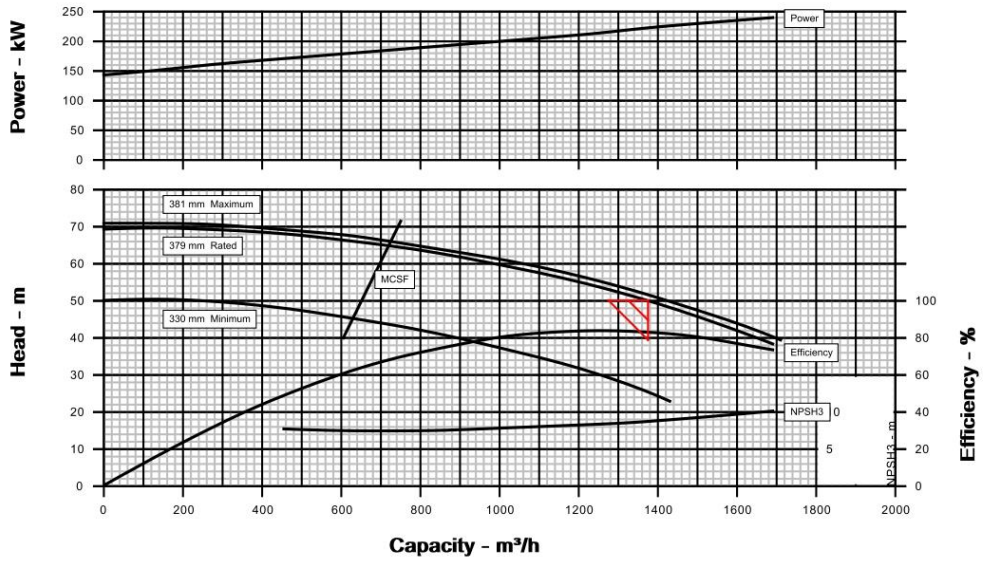
Hydraulic Datasheet

Customer	: Xenia Balague	Pump / Stages	: 3K10x8M-16H/15RVSM / 1
Customer reference	: -	Based on curve no.	: MIII8435V
Item number	: -	Flowserve reference	: 4574534422
Service	: -	Date	: August 1, 2023

Operating Conditions		Materials / Specification	
Capacity (rated/normal)	: 1,375.0 m³/h / -	Material column code	: DCI
Water capacity (CQ=1.00)	: -	Pump specification	: -
Total developed head	: 50.00 m	**Other Requirements**	
Water head (CH=1.00)	: -	Hydraulic selection : No specification	
NPSHa/NPSHa less margin	: 9.7 m / -	Construction : No specification	
Maximum suction pressure	: 0.0 kPa.g	Test tolerance : ANSI/HI 14.6 Grade 1B	
Liquid		Driver Sizing : API 610	
Liquid type	: Fresh water	Seal configuration : Repeller Design	
Liquid description	: -		
Temperature	: 40 °C		
Density / Specific gravity	: - / 0.992		
Solid Size - Actual / Limit	: - / 41 mm		
Viscosity / Vapor pressure	: 1.00 cP / 7.35 kPa.a		

Performance			
Hydraulic power	: 186 kW	Impeller diameter	
Pump speed	: 1,780 rpm	Rated	: 379 mm
Pump overall efficiency (CE=1.00)	: 83.6 %	Maximum	: 381 mm
NPSH required (NPSH3)	: 8.7 m	Minimum	: 330 mm
Rated brake power	: 222 kW	Ns / Nss (per eye)	: 53 / 216 (SI)
		Minimum continuous flow	: 721.0 m³/h
Maximum brake power	: 240 kW	Maximum head at rated diameter	: 69.36 m
Driver power rating	: 350 hp / 261 kW	Flow at BEP	: 1,263.1 m³/h
Casing working pressure	: 674.0 kPa.g	Flow as % of BEP	: 108.9 %
(based on shut off @ cut dia/rated SG)		Efficiency at normal flow	: -
Maximum allowable	: 1,719.1 kPa.g	Impeller diameter ratio (rated/max)	: 99.6 %
Hydrostatic test pressure	: 2,951.0 kPa.g	Head rise to shut off	: 38.7 %
Estimated rated seal chamber pressure	: -	Total head ratio (rated / max) / (max / rated)	: 96.8 % / 103.3 %

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS; CAPACITY, HEAD, AND EFFICIENCY.



Affinity v2.22.0

FLOWSERVE

Construction Datasheet

Customer	: Xenia Balague	Pump / Stages	: 3K10x8M-16H/15RVSM / 1
Customer reference	: -	Based on curve no.	: MIII8435V
Item number	: -	Flowserve reference	: 4574534422
Service	: -	Date	: August 1, 2023

Construction

Nozzles	Size	Rating	Face	Position
Suction	10.00	-	-	End
Discharge	8.00	-	-	Top

Casing mounting	: Foot
Casing split	: Radial
Impeller type	: Reverse Vane
Bearing type (radial)	: -
Bearing number (radial)	: -
Bearing type (thrust)	: -
Bearing number (thrust)	: -
Bearing lubrication	: -
Rotation (view from driver)	: CW per Hyd. Institute

Materials

Casing	: -
Impeller	: -
Seal chamber	: -
Shaft	: -
Sleeve	: -

Baseplate, Coupling and Guard

Baseplate type	: -
Baseplate material	: -
Baseplate size	: -
Coupling manufacturer	: Not Supplied
Coupling size	: -
Coupling / Shaft guard	: -
Shaft / seal guard	: -

Weights (Approx.)

Bareshaft pump (net)	: 450.0 kg
Baseplate (net)	: -
Driver (net)	: -
Shipping gross weight/volume	: *** / ***

Testing

Hydrostatic test	: -
Performance test	: Other
NPSH test	: -

Paint and Package

Pump paint	: -
Base grout surface prep	: N/A
Shipment type	: -

Driver Information

Manufacturer	: -
Power	: 350 hp / 261 kW
Service factor (requested / actual)	: 1.0 / -
Synchronous speed	: 1,800 rpm
Orientation / Mounting	: Horizontal / -
Driver type	: -
Frame-size / material	: - / -
Enclosure	: -
Hazardous area class	: -
Explosion 'T' rating	: -
Volts / Phase / Hz	: 460 / 3 / 60 Hz
Amps-full load/locked rotor	: - / -
Motor starting	: Direct on line (DOL)
Insulation	: -
Temperature rise	: -
Bearings	: -
Lubrication	: -
Motor mounted by	: -

Sound Pressure (dBA @ 1.0 m)

Driver, expected	: -
Pump & driver, estimated	: Refer to Factory

Seal Information

Arrangement	: -
Size	: 2.625 Inch
Manufacturer / Type	: N/A / N/A
Material code (Man'f/API)	: As Specified / N/A
Internal neck bushing	: N/A

Gland

Gland material	: -
Flush	: N/A
Vent	: N/A
Drain	: N/A
Auxiliary seal device	: -

Piping

Seal flush plan	: -
Seal flush construction	: -
Seal flush material	: -
Aux seal flush plan	: None
Aux seal flush construction	: -
Aux seal flush material	: -

Notes

-

-

-

-

-

-

Affinity v2.22.0

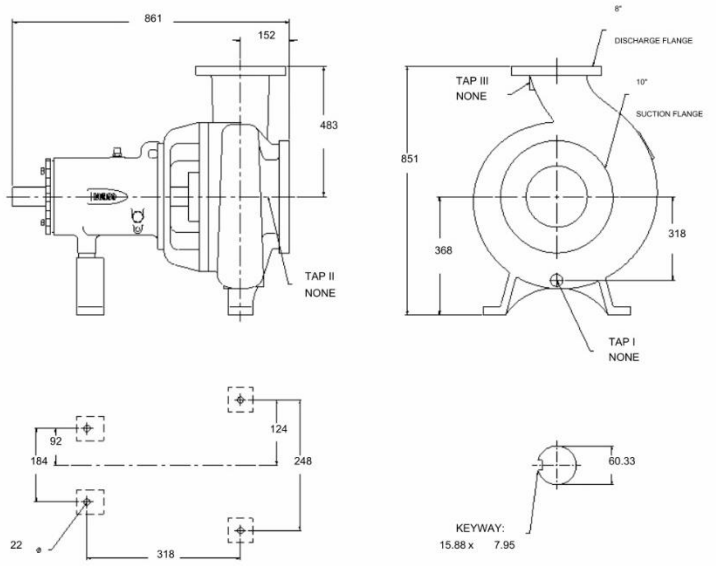
FLOWSERVE

Full Page GA Drawing

Dimensions certified for construction
when properly endorsed below.
Refer to factory for any "*" dimensions.
DO NOT SCALE DRAWING

NOTES:
1. Consult pump I.O.M. before installing the pump.
2. Installation dimensions are +/- .13" (3mm), unless otherwise noted.
3. Foundation bolts and piping should not be set rigidly before receipt of equipment.
4. Allow a minimum of .75" (19mm) under baseplate for adjustment and grouting.
5. All holes in flanges straddle centerlines.
6. Piping, foundations, and systems are the responsibility of others. Flowserve Pump Division data and comments are offered as an aid, but Flowserve Pump Division cannot assume responsibility for the system design or operation. It is recommended that a specialist skilled in this area be consulted to ensure a successful installation.

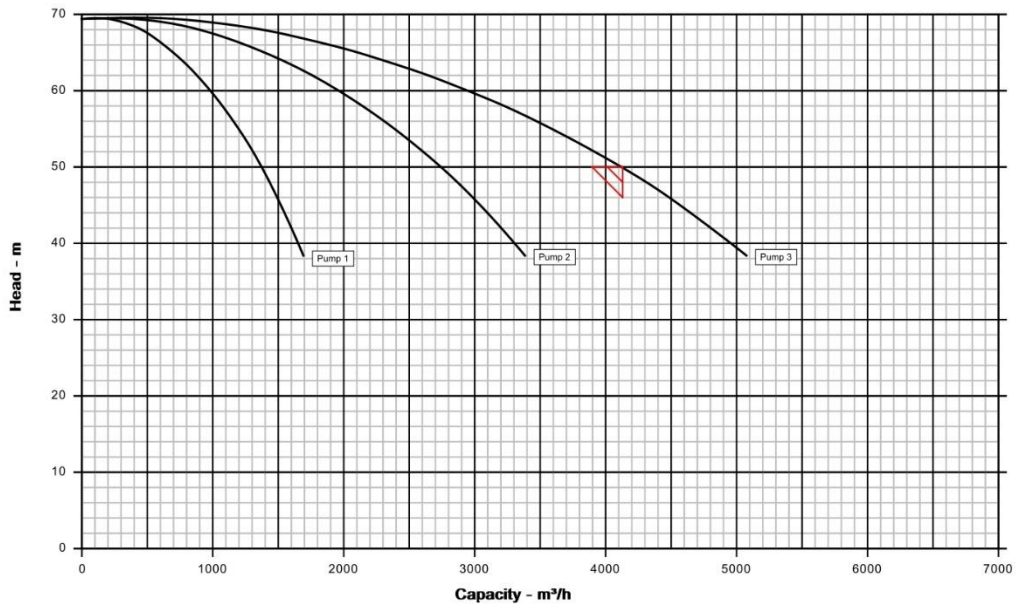
Pump Shaft Dia. at Seal: 2.625"



Customer	: Xenia Balague	Pump size & type	: 3K10x8M-16H/15RVSM	Drawing number	: -
Item number	: -	Pump speed / Stages	: 1,780 rpm / 1	Date	: August 1, 2023
Service	: -	Flow / Head	: 1,375.0 m³/h / 50.00 m	Certified by / Date :	: -
Customer PO #	: -	Driver power / Frame	: 350 hp / 261 kW / -	Seal type	: N/A
Flowserve reference	: 4574534422	Volts / Phase / Hz	: 460 / 3 / 60 Hz	Seal flush plan	: -

Customer	: Xenia Balague			Capacity	: 1,375.0 m³/h
Item number	: -			Head	: 50.00 m
Service	: -			Density / Specific gravity	: - / 0.992
Flowserve reference	: 4574534422			Pump speed	: 1,780 rpm
Pump size & type / Stages	: 3K10x8M-16H/15RVSM	/ 1		Ns / Nss (per eye)	: 53 / 216 (SI)
Based on curve no.	: MIII8435V				
Impeller diameter	: 379 mm			Date	: August 1, 2023

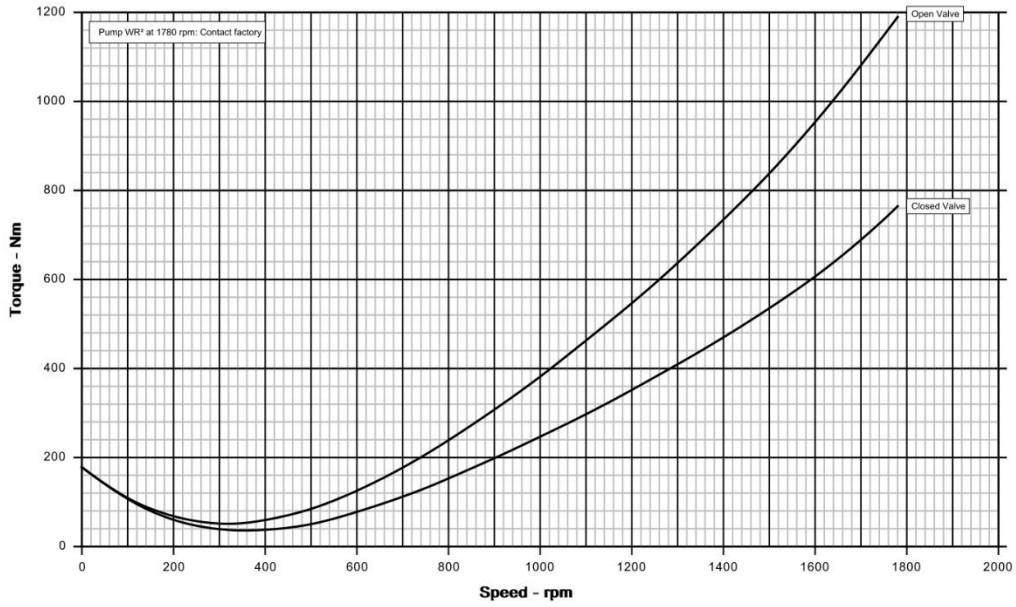
CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS: CAPACITY, HEAD, AND EFFICIENCY.



Affinity v2.22.0

Customer	: Xenia Balague			Capacity	: 1,375.0 m³/h
Item number	: -			Head	: 50.00 m
Service	: -			Density / Specific gravity	: - / 0.992
Flowserve reference	: 4574534422			Pump speed	: 1,780 rpm
Pump size & type / Stages	: 3K10x8M-16H/15RVSM	/ 1		Ns / Nss (per eye)	: 53 / 216 (SI)
Based on curve no.	: MIII8435V			Pump WR² at 1,780 rpm	: -
Impeller diameter	: 379 mm				
				Date	: August 1, 2023

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS: CAPACITY, HEAD, AND EFFICIENCY.



Affinity v2.22.0

5.4 Make-up pump

GRUNDFOS

Company name:
Created by:
Phone:

Date: 01/08/2023

Qty.	Description
1	**MAGNA3 80-120 F**

Note! Product picture may differ from actual product

Product No.: 97924320

The Grundfos MAGNA3 circulator pump is the ideal choice for almost any building project – old or new. With its unrivalled energy efficiency, all-encompassing range and built-in communication capabilities, MAGNA3 is ideal for engineers and specifiers looking to create high-performance heating and cooling systems.

The pump is maintenance-free due to the canned-rotor type design. This also means that pump and motor form an integral unit without shaft seal and with only two gaskets for sealing. The bearings are lubricated by the pumped liquid.

MAGNA3 features an intuitive display and allows you to connect wirelessly with the Grundfos GO Remote app, giving you access to advanced reporting and monitoring.

MAGNA3 model E has Bluetooth, which allows you to connect directly to Grundfos Go app on your smart phone without any need for a dongle.

The pump includes fieldbus communication via CIM modules as well as analog and digital inputs and configurable relays.

Control features include AUTOADAPT and FLOWADAPT. FLOWADAPT which reduces the need for throttling valves, thus cutting costs on system components.

MAGNA3 is the superior choice for a wide range of heating and cooling applications, including:

- Mixing loops
  Heating surfaces
  Air conditioning surfaces
  Ground-source heat pump systems
  Smaller chiller applications.

MAGNA3 is a single-phase pump and characterised by having the controller and control display integrated in the control box. The pump also has a built-in differential-pressure and temperature sensor.

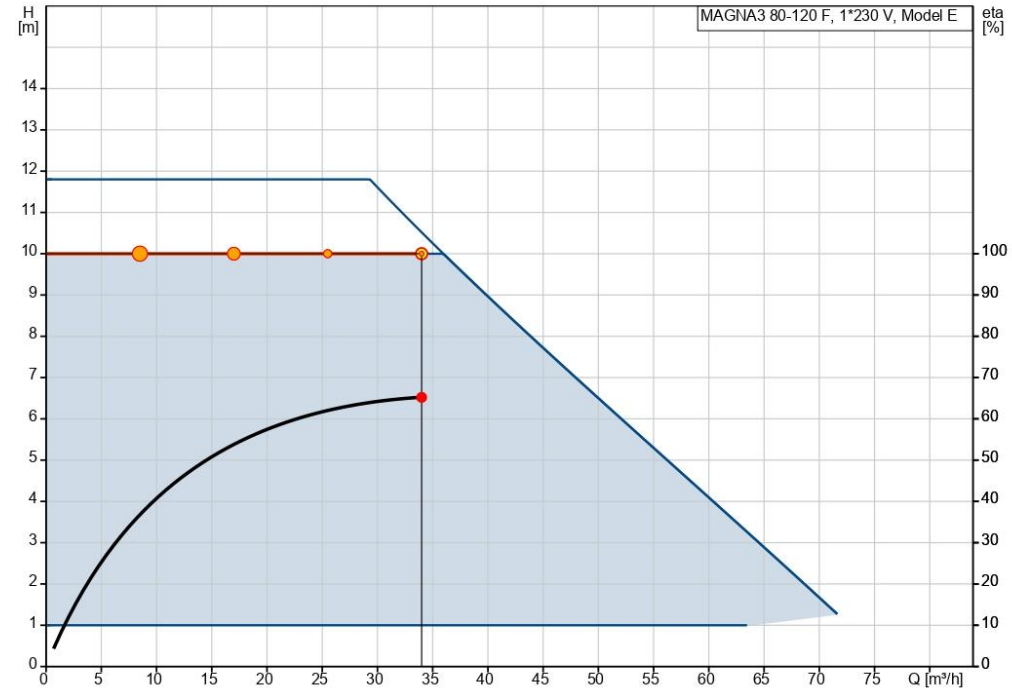
The pump housing is available in both cast-iron and stainless-steel versions. The composite rotor can is carbon-fibre reinforced, the bearing plate and rotor cladding are made of stainless steel and the stator housing is made of aluminium. The power electronics are air-cooled.

MAGNA3 incorporates a 4-pole synchronous, permanent-magnet motor (PM motor). This motor type is characterised by higher efficiency than a conventional asynchronous squirrel-cage motor. The pump speed is controlled by an integrated frequency converter.

Company name:
Created by:
Phone:

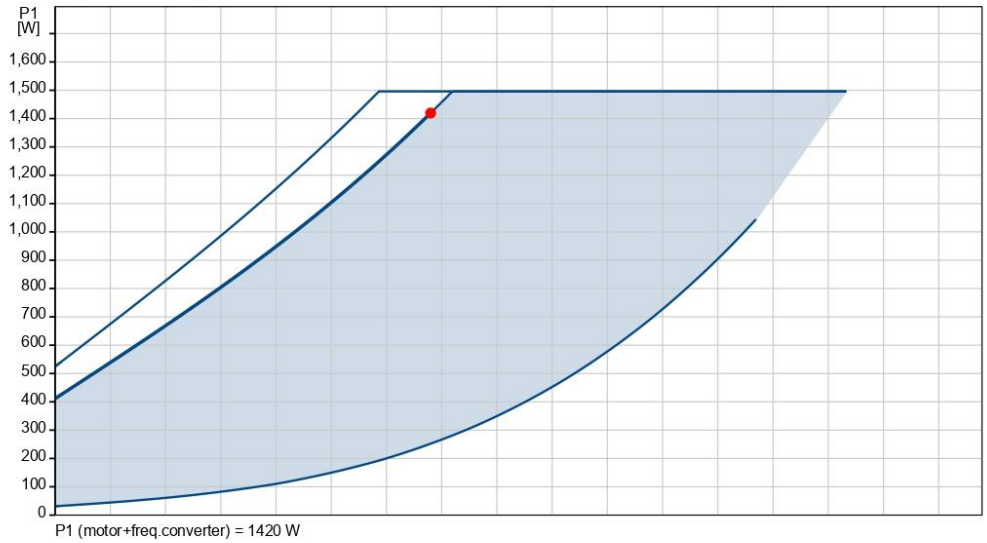
Date: 01/08/2023

97924320 MAGNA3 80-120 F



Q = 34 m³/h
n = 94 % / 3466 rpm
Liquid temperature during operation = 20 °C
Eta pump+motor+freq.converter = 65.2 %

H = 10 m
Pumped liquid = Cold water / cooling water
Density = 999.9 kg/m³



P1 (motor+freq.converter) = 1420 W

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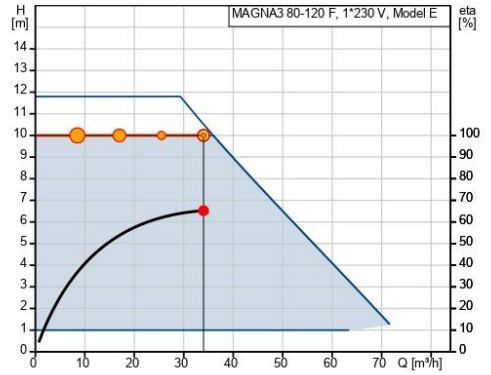
2/7

GRUNDFOS

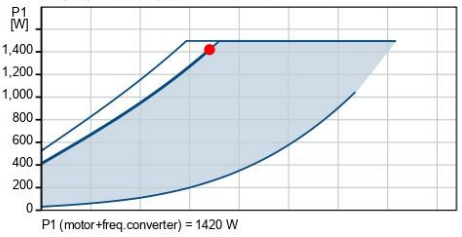
Company name:
Created by:
Phone:

Date: 01/08/2023

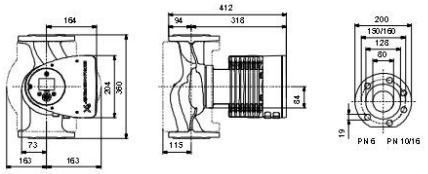
Description	Value
General information:	
Product name:	MAGNA3 80-120 F
Product No:	97924320
EAN number:	5710626493968
Price:	EUR 7544
Technical:	
Pump speed on which pump data are based:	3466 rpm
Actual calculated flow:	34 m³/h
Resulting head of the pump:	10 m
Head max:	120 dm
TF class:	110
Approvals:	CE,VDE,EAC,MOROCCO,UKCA, TSERCM,UkrSEPRO
Model:	E
Materials:	
Pump housing:	Cast iron
Pump housing:	EN-GJL-250
Pump housing:	ASTM A48-250B
Impeller:	PES 30%GF
Installation:	
Range of ambient temperature:	0 .. 40 °C
Maximum operating pressure:	10 bar
Flange standard:	DIN
Pipe connection:	DN 80
Pressure rating:	PN 10
Port-to-port length:	360 mm
Liquid:	
Pumped liquid:	Cold water / cooling water
Liquid temperature range:	-10 .. 110 °C
Selected liquid temperature:	20 °C
Density:	999.9 kg/m³
Electrical data:	
Power input - P1:	31 .. 1496 W
Mains frequency:	50 / 60 Hz
Rated voltage:	1 x 230 V
Maximum current consumption:	0.32 .. 6.65 A
Enclosure class (IEC 34-5):	X4D
Insulation class (IEC 85):	F
Others:	
Energy (EEI):	0.17
Net weight:	29.7 kg
Gross weight:	32.4 kg
Shipping volume:	0.071 m³
Danish VVS No.:	380965812
Swedish RSK No.:	5732521
Finnish LVI No.:	4615168
Norwegian NRF no.:	9042715
Country of origin:	DE
Custom tariff no.:	84137030
Environmental approvals:	CN ROHS,WEEE

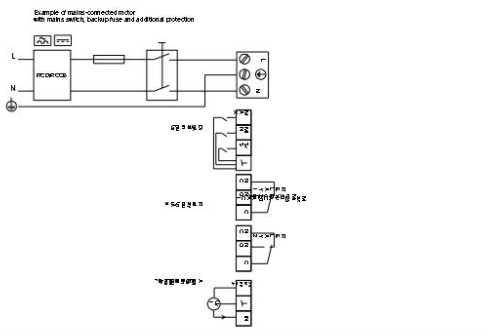


Q = 34 m³/h H = 10 m
n = 94 % / 3466 rpm Density = 999.9 kg/m³
Pumped liquid = Cold water / cooling water
Liquid temperature during operation = 20 °C
Eta pump+motor+freq.converter = 65.2 %



P1 (motor+freq.converter) = 1420 W





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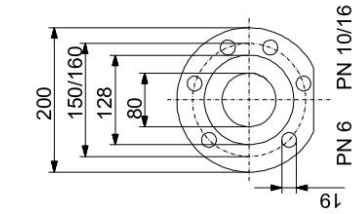
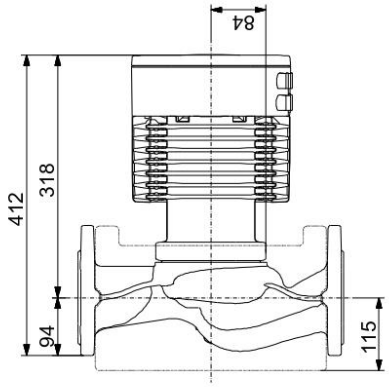
GRUNDFOS

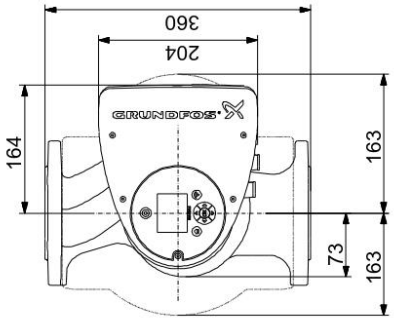
Company name:
Created by:
Phone:

Date: 01/08/2023

97924320 MAGNA3 80-120 F







Note! All units are in [mm] unless others are stated.
Disclaimer: This simplified dimensional drawing does not show all details.

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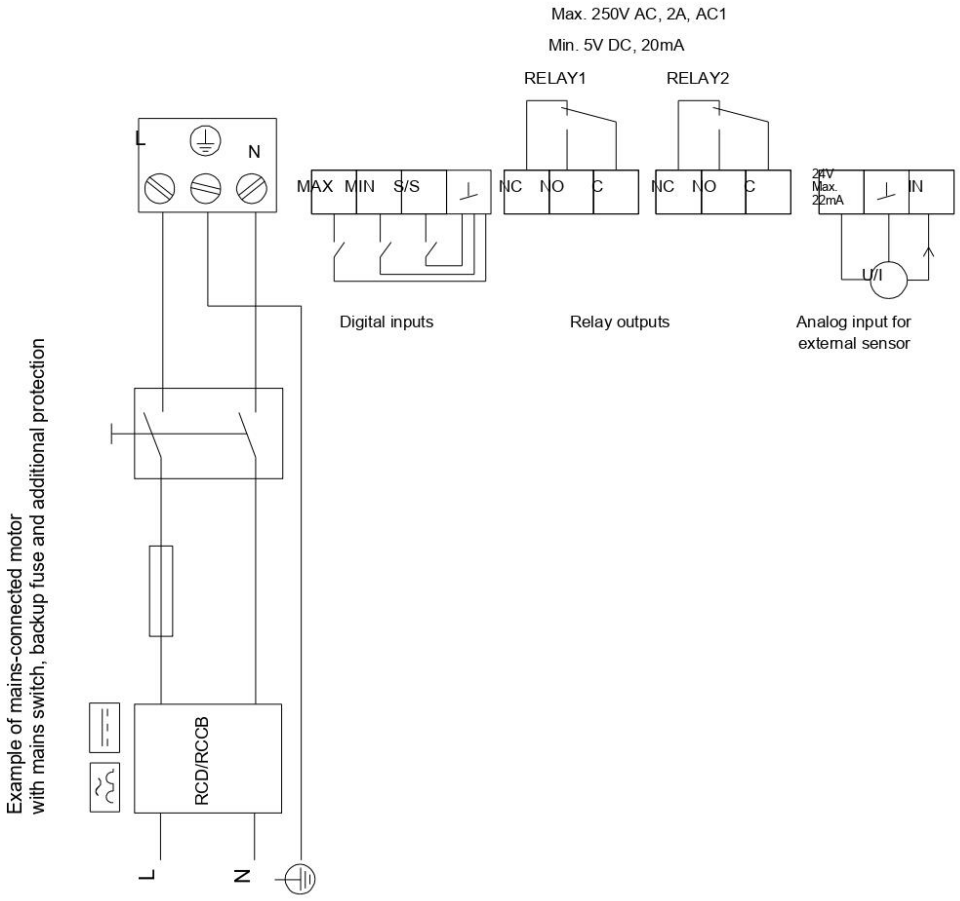
GRUNDFOS

Company name:
Created by:
Phone:

Date: 01/08/2023

97924320 MAGNA3 80-120 F



Note! All units are in [mm] unless others are stated.

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GRUNDFOS

Company name:
Created by:
Phone:

Date: 01/08/2023

97924320 MAGNA3 80-120 F

Input

Size by	Pump design
Journey	Sizing
Pump design	Circulator pumps

General

Select application	Air-conditioning
Application area	Industrial plant service systems
Installation type	Cooling tower open
Installation	One tower
Select type of hydraulic	Single
Flow (Q)	34 m³/h
Head (H)	10 m
BMS connectivity	No
Evaluation criterion	Preference index
Prefer fast delivery	No

Your requirements

Pumped liquid	Cold water / cooling water
Min. liquid temperature	6 °C
Max. liquid temperature	40 °C
Max. operation pressure	10 bar
Allowed flow undersize	10 %
Min. inlet pressure	1.5 bar

Control mode

Control mode	Const. pressure
Pumps with external frequency converter	Both 50 Hz and 60 Hz
Enclosure class	IP20
Cabinet wanted	No
Allow fixed speed	No
Remote controlled by external controller	No

Edit load profile

Yearly operation time	100 days
Load profile	Standard profile

Operational conditions

Frequency	50 Hz
Phase	1 or 3
Min. power limit for SD start	5.5 kW
Voltage	1 x 230 or 3 x 400 V
Ambient temperature	20 °C

Life cycle cost

Do you want to make a comparison?	No comparison
How detailed do you want your life cycle cost analysis?	Simple LCC analysis
	Pump A

Hit list settings

Include cheapest solution	Yes
Max. hits per product group	2
Max. hits total	8
Energy price	0.28 EUR/kWh
Increase of energy price	6 %
CO2 emission intensity	0.26 kg/kWh
Calculation period	15 years

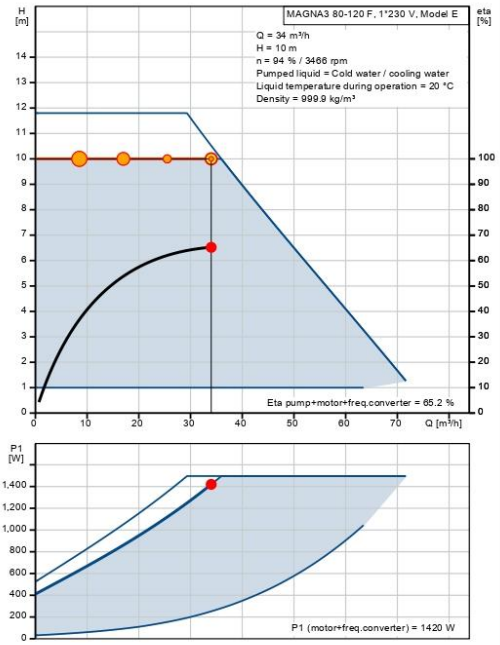
Load Profile

	1	2	3	4
Flow (%)	25	50	75	100
Flow (m³/h)	8.5	17	25.5	34
Head (%)	100	100	100	100
Head (m)	10	10	10	10
P1 (kW)	0.629	0.861	1.12	1.42
Eta total (%)	36.8	53.8	62.0	65.2
Time (h/a)	1056	840	360	144
Energy consumption (kWh/Year)	665	723	403	204
Quantity	1	1	1	1

Sizing result

Type MAGNA3 80-120 F
Quantity 1
Motor

Flow	34	m³/h
Head	10	m
Power P1	1.42	kW
Eta pump+motor	65.2	% =Eta pump * Eta motor
Eta total	65.2	% =Eta relative to the duty point
Energy consumption	1995	kWh/Year
CO2 emission	529	kg/Year
Price	7.544,00	EUR
Life cycle cost	20932	EUR /15Years



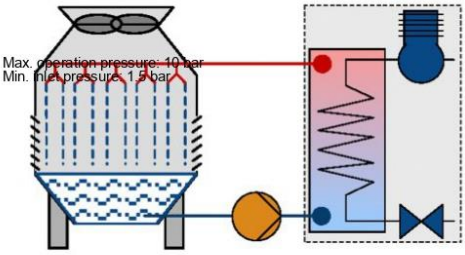
Company name:
Created by:
Phone:

Date: 01/08/2023

Installation and Input

Flow (Q): 34 m³/h Head (H): 10 m

Pumped liquid: Agua fría / agua refrigerente



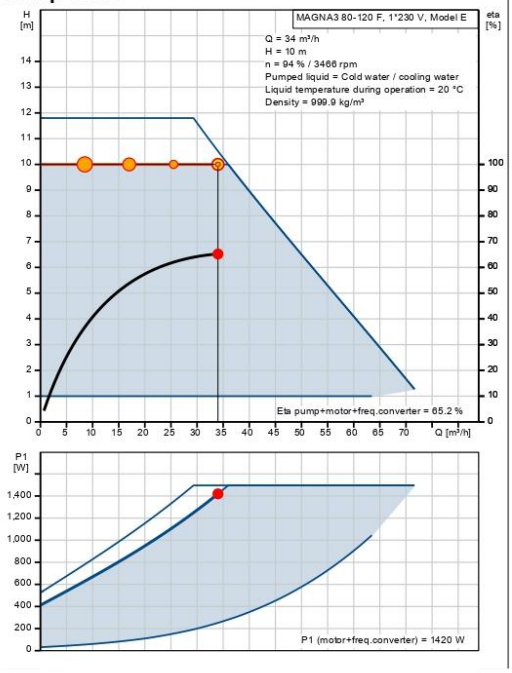
Sizing Results

Product number:	97924320
Type:	MAGNA3 80-120 F
Quantity:	1
Motor:	
Flow:	34 m³/h
Head:	10 m
Power P1:	1.42 kW
Eta pump+motor:	65.2 % =Eta pump * Eta motor
Eta total:	65.2 % =Eta relative to the duty point
Energy consumption:	1995 kWh/Year
CO2 emission:	529 kg/Year
Price:	7.544,00 EUR

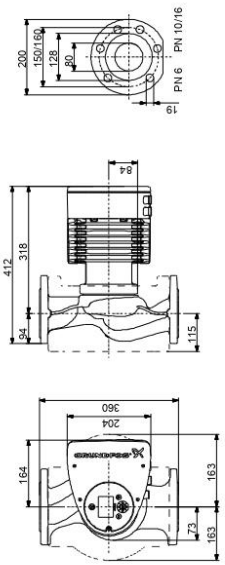
Load profile

	1	2	3	4
Flow (%)	25	50	75	100
Flow (m³/h)	8.5	17	25.5	34
Head (%)	100	100	100	100
Head (m)	10	10	10	10
P1 (kW)	0.629	0.861	1.12	1.42
Eta total (%)	36.8	53.8	62.0	65.2
Time (h/a)	1056	840	360	144
Energy consumption (kWh/Year)	665	723	403	204
Quantity	1	1	1	1

Pump Curve



Dimensional Drawing



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5.5 Sulfuric acid pump

GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

Pumped Liquid Guide Report

Name	Value	Unit
Liquid Specification		
Filter liquids		
Liquid	H2SO4 (Sulfuric acid)	
Concentration	98	%
Liquid temperature during operation	20	°C
Pump Selection		
Pump family	Dosing pumps, Digital	
Pump subfamily	DDC	
Configuration	Standard	
Version	DDC	
Pump head material		
Valve balls		
Gaskets	PTFE	
Number of hits	72	

Liquid Info

H2SO4 (Sulfuric acid)

Sulfuric acid: H2SO4, corrosive, oily, colourless liquid, with a specific gravity of 1.85.
Melting point: 10 °C.
Boiling point 340 °C.
(pH value 1 at 25%, 20 °C)
Sulfuric acid is soluble in all proportions in water.

When sulfuric acid is mixed with water, considerable heat is released. Unless the mixture is well stirred, the added water may be heated beyond its boiling point and the sudden formation of steam may blow the acid out of its container.

Properties: Sulfuric acid is a strong acid, that in aqueous solution is largely changed to hydrogen ions (H+) and sulfate ions (SO4--). Each molecule gives two H+ ions, thus sulfuric acid is dibasic. Dilute solutions of sulfuric acid show all the behavior characteristics of acids. They taste sour, conduct electricity, neutralize alkalies, and corrode active metals with formation of hydrogen gas.

Concentrated sulfuric acid, formerly called oil of vitriol, is a valuable desiccating agent. It acts so vigorously in this respect that it removes water from (and therefore chars) wood, cotton, sugar, and paper. It is used in the manufacture of ether, nitroglycerin, and dyes for its property as a desiccant. When concentrated sulfuric acid is heated, it behaves also as an oxidizing agent, capable, for example, of dissolving such relatively unreactive metals as copper, mercury, and lead to produce metal sulfate, sulfur dioxide, and water.

Use: The uses of sulfuric acid are so varied that the volume of its production provides an approximate index of general industrial activity. American production of sulfuric acid exceeded 29 million tons annually in the early 1970s, a figure corresponding to a daily production of 1/3 kg (3/4 lb) per person throughout the year. The largest single use of sulfuric acid is for making fertilizers, both superphosphate and ammonium sulfate. It is also used in making organic products, refining petroleum, making paints and pigments, processing metals, and making rayon. One of the few consumer products containing sulfuric acid as such is the lead storage battery, or car energizer.

GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

Qty.	Description
1	**DDC 6-10**

Note! Product picture may differ from actual product

Product No.: 97721352
DDC 6-10 A-PV/T/C-F-31U2U2FG

The SMART Digital DDC is a compact positive displacement, diaphragm dosing pump with variable-speed drive (stepper motor) and intelligent control electronics with minimum energy consumption.

The SMART Digital Dosing series operates at full stroke length to ensure optimum accuracy, priming and suction, even for high-viscosity or degassing liquids.

The duration of each discharge stroke varies according to the capacity set, resulting in optimum smooth and continuous discharge flow.

The click-stop mounting plate allows installation in three different positions without using any additional accessories.

The control cube can be turned easily into front, left or right position.

The click wheel and the multi-coloured backlit graphical, plain-text LC display make commissioning and operation intuitive.

The control elements are protected by a transparent cover.

The dosing head is composed of:

- Long lifetime and universal, chemically resistant full-PTFE diaphragm.
- Double ball valves for highest dosing accuracy.
- Deaeration valve for easy start-up.

Operation modes:

- Manual dosing in ml/h, l/h or gph.
- Pulse control in ml/pulse (incl. memory function).

Other features:

- Two SlowMode steps (anti-cavitation), 50 % (maximum flow= 3 l/h) and 25 % (maximum flow= 1.5 l/h), e.g. for high-viscosity or degassing liquids.
- Service information display to show when service and which wear-part order number is required.
- Two-step key lock function to protect the pump against unauthorised access.
- Additional display function to provide further information.
- Counter for total dosed volume (resettable), operating hours and others.
- Save and load customised settings as well as reload of factory settings.

Signal inputs/outputs:

- Input for pulse, external stop.
- Input for low-level and empty-tank signal.

Technical:

Type key:	DDC 6-10 A-PV/T/C-F-31U2U2FG
Max. Flow:	6 l/h
Max. flow in slow mode 50%:	3 l/h
Max. flow in slow mode 25%:	1.5 l/h
Min flow:	6.0 ml/h
Turn-down ratio:	1:1000
Approvals:	CE,CSA-US,NSF61,EAC,RCM
Valve type:	Standard

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GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

Qty.	Description	
1	Maximum viscosity at 100 %:	50 mPas
	Maximum viscosity in slow mode 50 %:	1800 mPas
	Maximum viscosity in slow mode 25 %:	2500 mPas
	Accuracy of repeatability:	1 %
	Materials:	
	Dosing head:	PVDF (Polyvinylidene fluoride)
	Valve ball:	Ceramic
	Gasket:	PTFE
	Installation:	
	Range of ambient temperature:	0 .. 45 °C
	Maximum operating pressure:	10 bar
	Installation set:	NO
	Installation type:	No installation set
	Pump inlet:	4/6, 6/9, 6/12, 9/12 mm
	Pump outlet:	4/6, 6/9, 6/12, 9/12 mm
	Max. Suction lift during operation:	6 m
	Max. Suction lift during priming:	2 m
	Liquid:	
	Pumped liquid:	Sulfuric acid
	Liquid temperature range:	-10 .. 45 °C
	Concentration:	98 %
	Selected liquid temperature:	20 °C
	Density:	998.2 kg/m³
	Electrical data:	
	Maximum power input - P1:	22 W
	Mains frequency:	50 Hz
	Rated voltage:	1 x 100-240 V
	Enclosure class (IEC 34-5):	IP65 / NEMA 4X
	Length of cable:	1.5 m
	Type of cable plug:	EU
	Inrush current:	25A at 230V for 2ms
	Controls:	
	Control variant:	A
	Level control:	YES
	Pulse control:	YES
	Ext. Stop input:	YES
	Others:	
	Net weight:	2 kg
	Gross weight:	3 kg
	Color:	RED

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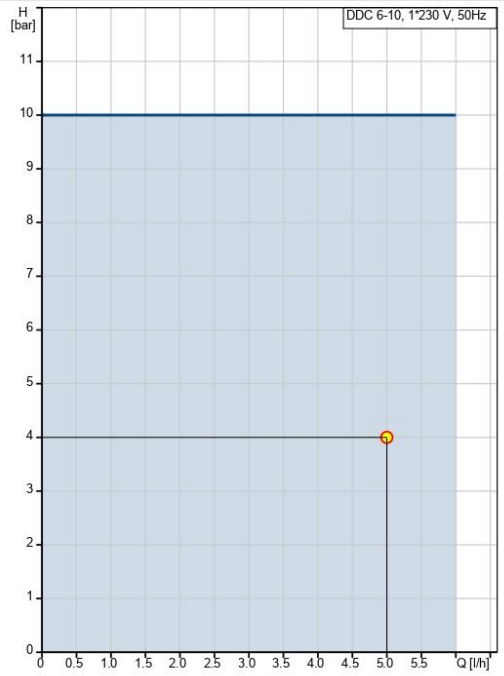
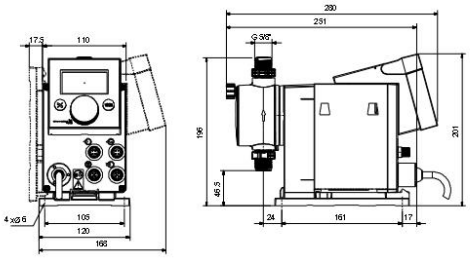
GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

Description	Value
General information:	
Product name:	DDC 6-10
Product No:	97721352
EAN number:	5710622714937
Technical:	
Type key:	DDC 6-10 A-PV/T/C-F-31U2U2FG
Max. Flow:	6 l/h
Max. flow in slow mode 50%:	3 l/h
Max. flow in slow mode 25%:	1.5 l/h
Min flow:	6.0 ml/h
Turn-down ratio:	1:1000
Approvals:	CE,CSA-US,NSF61,EAC,RCM
Valve type:	Standard
Maximum viscosity at 100 %:	50 mPas
Maximum viscosity in slow mode 50 %:	1800 mPas
Maximum viscosity in slow mode 25 %:	2500 mPas
Accuracy of repeatability:	1 %
Materials:	
Dosing head:	PVDF (Polyvinylidene fluoride)
Valve ball:	Ceramic
Gasket:	PTFE
Installation:	
Range of ambient temperature:	0 .. 45 °C
Maximum operating pressure:	10 bar
Installation set:	NO
Installation type:	No installation set
Pump inlet:	4/6, 6/9, 6/12, 9/12 mm
Pump outlet:	4/6, 6/9, 6/12, 9/12 mm
Max. Suction lift during operation:	6 m
Max. Suction lift during priming:	2 m
Liquid:	
Pumped liquid:	Sulfuric acid
Liquid temperature range:	-10 .. 45 °C
Concentration:	98 %
Selected liquid temperature:	20 °C
Density:	998.2 kg/m³
Electrical data:	
Maximum power input - P1:	22 W
Mains frequency:	50 Hz
Rated voltage:	1 x 100-240 V
Enclosure class (IEC 34-5):	IP65 / NEMA 4X
Length of cable:	1.5 m
Type of cable plug:	EU
Inrush current:	25A at 230V for 2ms
Controls:	
Control variant:	A
Control panel:	FRONT-MOUNTED
Level control:	YES
Pulse control:	YES
Ext. Stop input:	YES
Others:	
Net weight:	2 kg
Gross weight:	3 kg
Color:	RED





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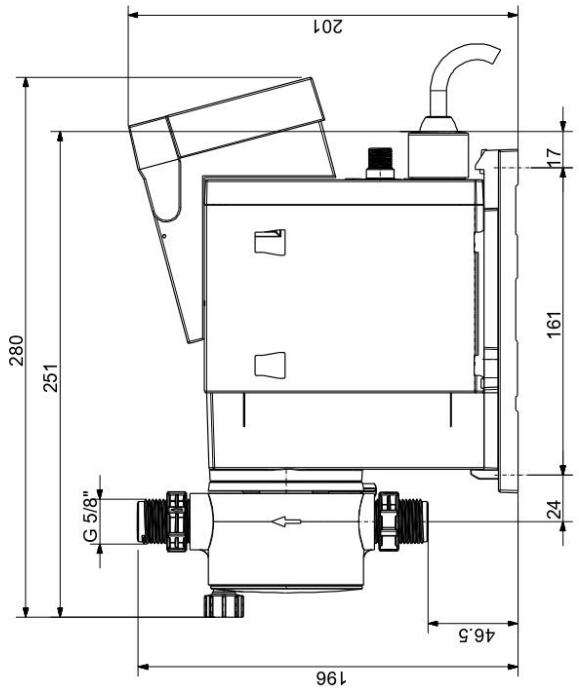
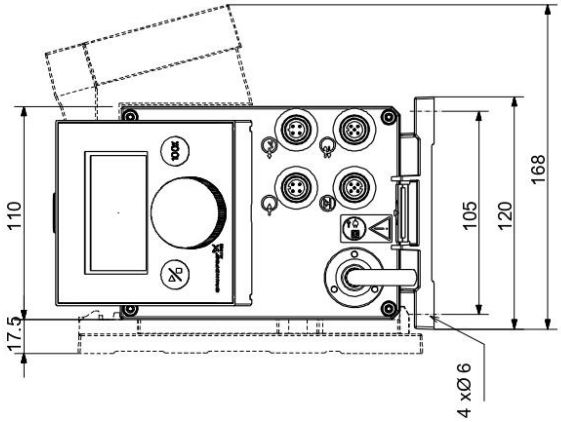
GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

97721352 DDC 6-10 50 Hz





Note! All units are in [mm] unless others are stated.
Disclaimer: This simplified dimensional drawing does not show all details.

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5.6 Sodium hypochlorite pump

Company name:
Created by:
Phone:

Date: 02/08/2023

Pumped Liquid Guide Report

Name	Value	Unit
Liquid Specification		
Filter liquids		
Liquid	NaClO (Sodium hypochlorite)	
Concentration	15	%
Liquid temperature during operation	25	°C
Pump Selection		
Pump family	Dosing pumps, Digital	
Pump subfamily	DDC	
Configuration	All	
Version	DDC	
Pump head material	PVC	
Valve balls	Ceramic	
Gaskets	PTFE	
Number of hits	12	

Liquid Info

NaClO (Sodium hypochlorite)

Sodium hypochlorite: NaClO is a pale greenish liquid with chlorine odour. Also known as soda bleach or liquid bleach. Household bleaches normally contain about 5% sodium hypochlorite (about pH11), and more concentrated bleaches contain 10-15% sodium hypochlorite (about pH13).Commercial sodium hypochlorites are normally stabilised with sodium hydroxide. Sodium hypochlorite should NEVER BE MIXED WITH ACIDS as chlorine (a toxic gas) will be liberated.

Melting point: -6 °C.
Boiling point: 40 °C (decomposes).
Specific gravity: 1.21.
pH value: 6 to 9.

Use: sodium hypochlorite is used for a wide range of applications where its powerful disinfection and oxidation properties are utilised. The main application areas include: Bleaching; Formulated Disinfectants; Potable and Waste Water Treatment; Swimming Pool Water Treatment; Process and Cooling Water Treatment; Odour Control; Chemical Intermediates; etc. Sodium hypochlorite is aggressive to many metals and elastomers.

Javelle water: aqueous solution of sodium or potassium hypochlorite. It was originally made near the French town of Javelle (now part of Paris) and was the first chemical bleach, a use first demonstrated by C. L. Berthollet in 1785. It was produced by passing chlorine gas through a water solution of potash (potassium carbonate). After the invention of bleaching powder Javelle water was sometimes produced by reacting the bleaching powder with potash or soda ash (sodium carbonate).

GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

Qty.	Description
1	**DDC 6-10**

Note! Product picture may differ from actual product

Product No.: 97721340
DDC 6-10 A-PVC/T/C-F-31U2U2FG

The SMART Digital DDC is a compact positive displacement, diaphragm dosing pump with variable-speed drive (stepper motor) and intelligent control electronics with minimum energy consumption.

The SMART Digital Dosing series operates at full stroke length to ensure optimum accuracy, priming and suction, even for high-viscosity or degassing liquids.

The duration of each discharge stroke varies according to the capacity set, resulting in optimum smooth and continuous discharge flow.

The click-stop mounting plate allows installation in three different positions without using any additional accessories.

The control cube can be turned easily into front, left or right position.

The click wheel and the multi-coloured backlit graphical, plain-text LC display make commissioning and operation intuitive.

The control elements are protected by a transparent cover.

The dosing head is composed of:

- Long lifetime and universal, chemically resistant full-PTFE diaphragm.
- Double ball valves for highest dosing accuracy.
- Deaeration valve for easy start-up.

Operation modes:

- Manual dosing in ml/h, l/h or gph.
- Pulse control in ml/pulse (incl. memory function).

Other features:

- Two SlowMode steps (anti-cavitation), 50 % (maximum flow= 3 l/h) and 25 % (maximum flow= 1.5 l/h), e.g. for high-viscosity or degassing liquids.
- Service information display to show when service and which wear-part order number is required.
- Two-step key lock function to protect the pump against unauthorised access.
- Additional display function to provide further information.
- Counter for total dosed volume (resettable), operating hours and others.
- Save and load customised settings as well as reload of factory settings.

Signal inputs/outputs:

- Input for pulse, external stop.
- Input for low-level and empty-tank signal.

Technical:

Type key:	DDC 6-10 A-PVC/T/C-F-31U2U2FG
Max. Flow:	6 l/h
Max. flow in slow mode 50%:	3 l/h
Max. flow in slow mode 25%:	1.5 l/h
Min flow:	6.0 ml/h
Turn-down ratio:	1:1000
Approvals:	CE,CSA-US,NSF61,EAC,RCM
Valve type:	Standard

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GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

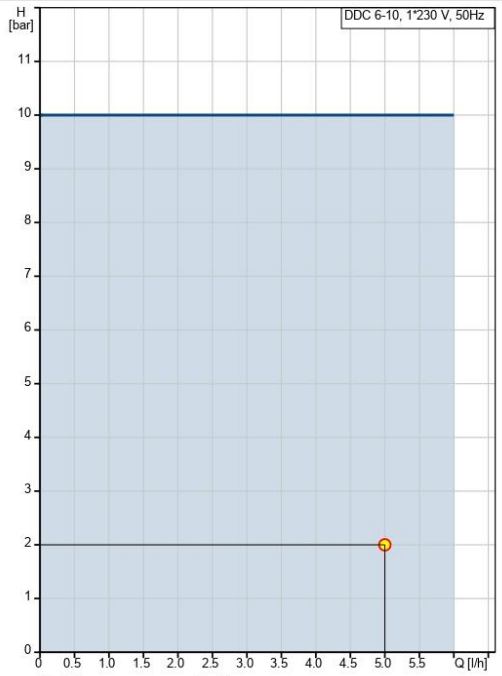
Qty.	Description	
1	Maximum viscosity at 100 %:	50 mPas
	Maximum viscosity in slow mode 50 %:	1800 mPas
	Maximum viscosity in slow mode 25 %:	2500 mPas
	Accuracy of repeatability:	1 %
	Materials:	
	Dosing head:	PVC (Polyvinyl chloride)
	Valve ball:	Ceramic
	Gasket:	PTFE
	Installation:	
	Range of ambient temperature:	0 .. 45 °C
	Maximum operating pressure:	10 bar
	Installation set:	NO
	Installation type:	No installation set
	Pump inlet:	4/6, 6/9, 6/12, 9/12 mm
	Pump outlet:	4/6, 6/9, 6/12, 9/12 mm
	Max. Suction lift during operation:	6 m
	Max. Suction lift during priming:	2 m
	Liquid:	
	Pumped liquid:	Hipoclorito de sodio
	Liquid temperature range:	-10 .. 45 °C
	Concentration:	15 %
	Selected liquid temperature:	25 °C
	Density:	998.2 kg/m³
	Electrical data:	
	Maximum power input - P1:	22 W
	Mains frequency:	50 Hz
	Rated voltage:	1 x 100-240 V
	Enclosure class (IEC 34-5):	IP65 / NEMA 4X
	Length of cable:	1.5 m
	Type of cable plug:	EU
	Inrush current:	25A at 230V for 2ms
	Controls:	
	Control variant:	A
	Level control:	YES
	Pulse control:	YES
	Ext. Stop input:	YES
	Others:	
	Net weight:	2 kg
	Gross weight:	3 kg
	Color:	RED
	Country of origin:	FR
	Custom tariff no.:	84135040

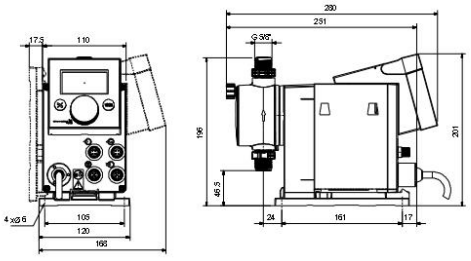
GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

Description	Value
General information:	
Product name:	DDC 6-10
Product No:	97721340
EAN number:	5710622714814
Price:	EUR 1372
Technical:	
Type key:	DDC 6-10 A-PVC/T/C-F-31U2U2FG
Max. Flow:	6 l/h
Max. flow in slow mode 50%:	3 l/h
Max. flow in slow mode 25%:	1.5 l/h
Min flow:	6.0 ml/h
Turn-down ratio:	1:1000
Approvals:	CE,CSA-US,NSF61,EAC,RCM
Valve type:	Standard
Maximum viscosity at 100 %:	50 mPas
Maximum viscosity in slow mode 50 %:	1800 mPas
Maximum viscosity in slow mode 25 %:	2500 mPas
Accuracy of repeatability:	1 %
Materials:	
Dosing head:	PVC (Polyvinyl chloride)
Valve ball:	Ceramic
Gasket:	PTFE
Installation:	
Range of ambient temperature:	0 .. 45 °C
Maximum operating pressure:	10 bar
Installation set:	NO
Installation type:	No installation set
Pump inlet:	4/6, 6/9, 6/12, 9/12 mm
Pump outlet:	4/6, 6/9, 6/12, 9/12 mm
Max. Suction lift during operation:	6 m
Max. Suction lift during priming:	2 m
Liquid:	
Pumped liquid:	Hipoclorito de sodio
Liquid temperature range:	-10 .. 45 °C
Concentration:	15 %
Selected liquid temperature:	25 °C
Density:	998.2 kg/m³
Electrical data:	
Maximum power input - P1:	22 W
Mains frequency:	50 Hz
Rated voltage:	1 x 100-240 V
Enclosure class (IEC 34-5):	IP65 / NEMA 4X
Length of cable:	1.5 m
Type of cable plug:	EU
Inrush current:	25A at 230V for 2ms
Controls:	
Control variant:	A
Control panel:	FRONT-MOUNTED
Level control:	YES
Pulse control:	YES
Ext. Stop input:	YES
Others:	
Net weight:	2 kg
Gross weight:	3 kg
Color:	RED





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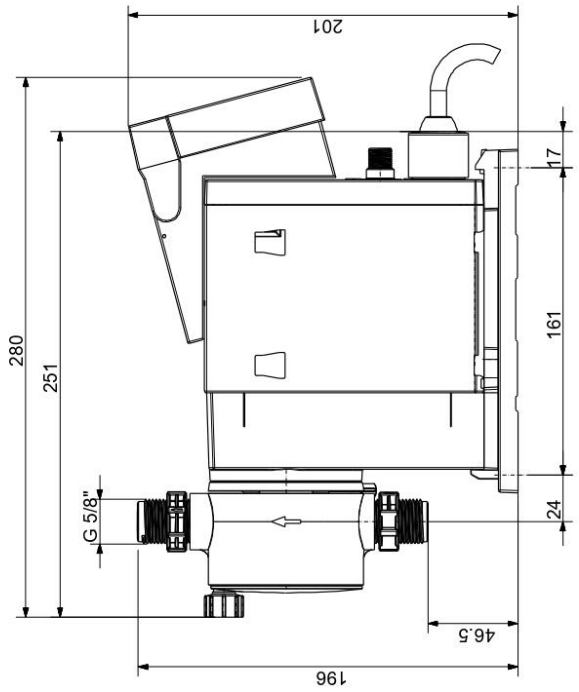
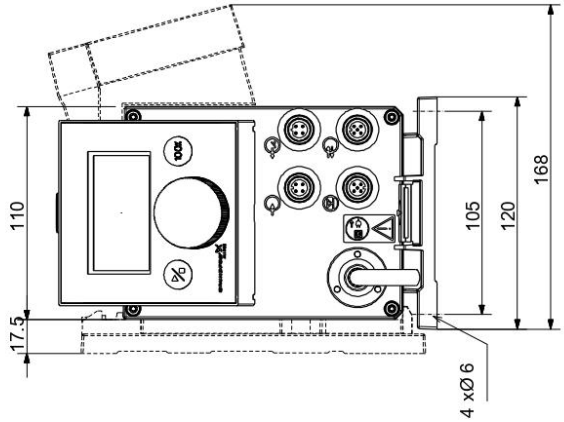
GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

97721340 DDC 6-10 50 Hz





Note! All units are in [mm] unless others are stated.
Disclaimer: This simplified dimensional drawing does not show all details.

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5.7 Chemical injection pump

GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

Qty.	Description
1	**DDC 15-4**

Note! Product picture may differ from actual product

Product No.: 97721461
DDC 15-4 A-PP/E/C-F-31U2U2FG

The SMART Digital DDC is a compact positive displacement, diaphragm dosing pump with variable-speed drive (stepper motor) and intelligent control electronics with minimum energy consumption.

The SMART Digital Dosing series operates at full stroke length to ensure optimum accuracy, priming and suction, even for high-viscosity or degassing liquids.

The duration of each discharge stroke varies according to the capacity set, resulting in optimum smooth and continuous discharge flow.

The click-stop mounting plate allows installation in three different positions without using any additional accessories.

The control cube can be turned easily into front, left or right position.

The click wheel and the multi-coloured backlit graphical, plain-text LC display make commissioning and operation intuitive.

The control elements are protected by a transparent cover.

The dosing head is composed of:

- Long lifetime and universal, chemically resistant full-PTFE diaphragm.
- Double ball valves for highest dosing accuracy.
- Deaeration valve for easy start-up.

Operation modes:

- Manual dosing in ml/h, l/h or gph.
- Pulse control in ml/pulse (incl. memory function).

Other features:

- Two SlowMode steps (anti-cavitation), 50 % (maximum flow= 7.5 l/h) and 25 % (maximum flow= 3.75 l/h), e.g. for high-viscosity or degassing liquids.
- Service information display to show when service and which wear-part order number is required.
- Two-step key lock function to protect the pump against unauthorised access.
- Additional display function to provide further information.
- Counter for total dosed volume (resettable), operating hours and others.
- Save and load customised settings as well as reload of factory settings.

Signal inputs/outputs:

- Input for pulse, external stop.
- Input for low-level and empty-tank signal.

Technical:

Type key:	DDC 15-4 A-PP/E/C-F-31U2U2FG
Max. Flow:	15 l/h
Max. flow in slow mode 50%:	7.5 l/h
Max. flow in slow mode 25%:	3.75 l/h
Min flow:	15.0 ml/h
Turn-down ratio:	1:1000
Approvals:	CE,CSA-US,EAC,RCM
Valve type:	Standard

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GRUNDFOS

Company name:
Created by:
Phone:

Date: 02/08/2023

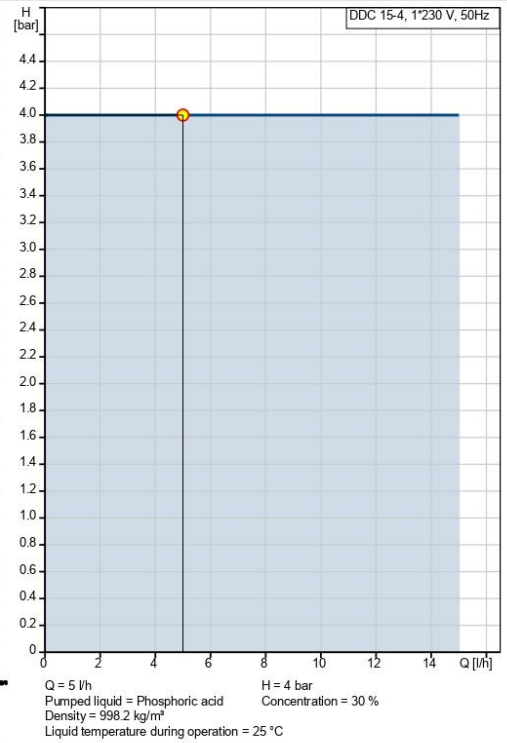
Qty.	Description	
1	Maximum viscosity at 100 %:	300 mPas
	Maximum viscosity in slow mode 50 %:	1300 mPas
	Maximum viscosity in slow mode 25 %:	2000 mPas
	Accuracy of repeatability:	1 %
	Materials:	
	Dosing head:	PP (Polypropylene)
	Valve ball:	Ceramic
	Gasket:	EPDM
	Installation:	
	Range of ambient temperature:	0 .. 45 °C
	Maximum operating pressure:	4 bar
	Installation set:	NO
	Installation type:	No installation set
	Pump inlet:	4/6, 6/9, 6/12, 9/12 mm
	Pump outlet:	4/6, 6/9, 6/12, 9/12 mm
	Max. Suction lift during operation:	6 m
	Max. Suction lift during priming:	3 m
	Liquid:	
	Pumped liquid:	Phosphoric acid
	Liquid temperature range:	-10 .. 45 °C
	Concentration:	30 %
	Selected liquid temperature:	25 °C
	Density:	998.2 kg/m³
	Electrical data:	
	Maximum power input - P1:	22 W
	Mains frequency:	50 Hz
	Rated voltage:	1 x 100-240 V
	Enclosure class (IEC 34-5):	IP65 / NEMA 4X
	Length of cable:	1.5 m
	Type of cable plug:	EU
	Inrush current:	25A at 230V for 2ms
	Controls:	
	Control variant:	A
	Level control:	YES
	Pulse control:	YES
	Ext. Stop input:	YES
	Others:	
	Net weight:	2 kg
	Gross weight:	3 kg
	Color:	RED

GRUNDFOS

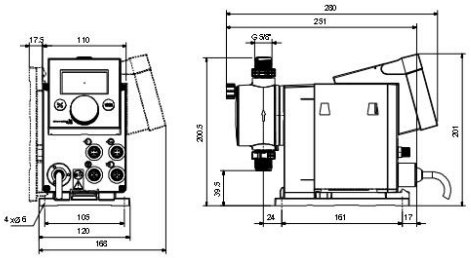
Company name:
Created by:
Phone:

Date: 02/08/2023

Description	Value
General information:	
Product name:	DDC 15-4
Product No:	97721461
EAN number:	5710622716023
Technical:	
Type key:	DDC 15-4 A-PP/E/C-F-31U2U2FG
Max. Flow:	15 l/h
Max. flow in slow mode 50%:	7.5 l/h
Max. flow in slow mode 25%:	3.75 l/h
Min flow:	15.0 ml/h
Turn-down ratio:	1:1000
Approvals:	CE,CSA-US,EAC,RCM
Valve type:	Standard
Maximum viscosity at 100 %:	300 mPas
Maximum viscosity in slow mode 50 %:	1300 mPas
Maximum viscosity in slow mode 25 %:	2000 mPas
Accuracy of repeatability:	1 %
Materials:	
Dosing head:	PP (Polypropylene)
Valve ball:	Ceramic
Gasket:	EPDM
Installation:	
Range of ambient temperature:	0 .. 45 °C
Maximum operating pressure:	4 bar
Installation set:	NO
Installation type:	No installation set
Pump inlet:	4/6, 6/9, 6/12, 9/12 mm
Pump outlet:	4/6, 6/9, 6/12, 9/12 mm
Max. Suction lift during operation:	6 m
Max. Suction lift during priming:	3 m
Liquid:	
Pumped liquid:	Phosphoric acid
Liquid temperature range:	-10 .. 45 °C
Concentration:	30 %
Selected liquid temperature:	25 °C
Density:	998.2 kg/m³
Electrical data:	
Maximum power input - P1:	22 W
Mains frequency:	50 Hz
Rated voltage:	1 x 100-240 V
Enclosure class (IEC 34-5):	IP65 / NEMA 4X
Length of cable:	1.5 m
Type of cable plug:	EU
Inrush current:	25A at 230V for 2ms
Controls:	
Control variant:	A
Control panel:	FRONT-MOUNTED
Level control:	YES
Pulse control:	YES
Ext. Stop input:	YES
Others:	
Net weight:	2 kg
Gross weight:	3 kg
Color:	RED



Q = 5 l/h
H = 4 bar
Pumped liquid = Phosphoric acid
Concentration = 30 %
Density = 998.2 kg/m³
Liquid temperature during operation = 25 °C



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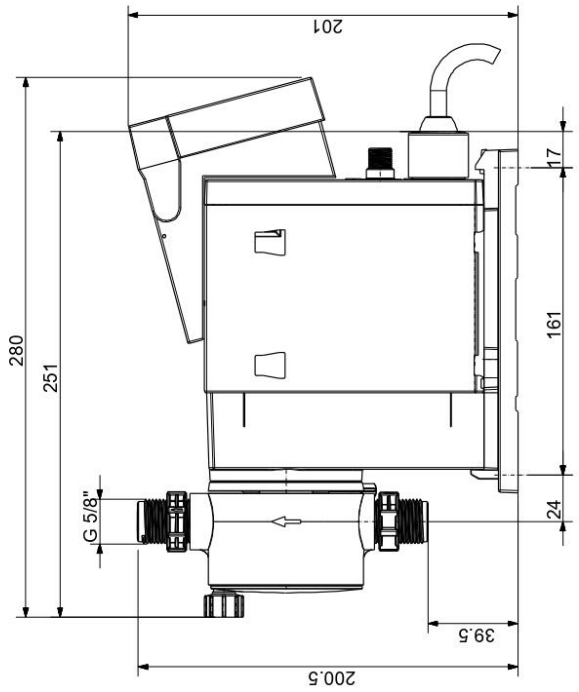
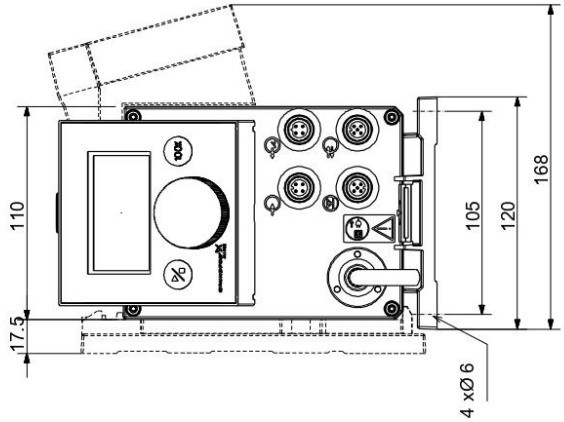
5/6

Company name:
Created by:
Phone:

Date: 02/08/2023

97721461 DDC 15-4 50 Hz





Note! All units are in [mm] unless others are stated.
Disclaimer: This simplified dimensional drawing does not show all details.

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6 Instrument list

6.1 Flow

Table 6.1. Flow instrument list.

INSTRUMENT Nº		FIT 1401	FIT 1402	FIT 1403	FIT 1404		
SERVICE / PURPOSE OF MEASUREMENT (control, information for BM, etc)		Control	Control	Control	Control		
Design Case		Operation	Operation	Operation	Operation		
GENERAL OPERATING DATA							
Nature of the fluid		L (Water)	L (Water)	L (Water)	L (Water)		
Corrosive / Toxic compounds (% weight / ppm p) (1)		-	-	-	-		
Phase (2)		L	L	L	L		
Normal flow: Liquid	**m^3/h**	30.85	2,500	2,500	7.65		
Gas	**Nm^3/h**	-	-	-	-		
Vapor	**kg/h**	-	-	-	-		
Minimum / Maximum flow rate	**%**	75-115	75-115	75-115	75-115		
Inlet temperature	**ºC**	16	32	26	26		
Inlet pressure	**kg/cm^2 g**	Atmospheric	4.0	Atmospheric	Atmospheric		
FLUID PROPERTIES							
Density @ P, T (3)	kg/m^3	1.120	1.174	1.174	1.174		
INSTRUMENT CHARACTERISTICS							
Type measurement		Vortex	Vortex	Vortex	Vortex		
Situation (4)		P	P	P	P		
Maximum DP at full scale	**mm ca**	-	-	-	-		
SET POINTS (Normal flow: 100%)							
High / Very High Alarm	**%**	110	110	110	110		
Low / Very Low Alarm	**%**	85	85	85	85		
High / Low Interlock	**%**	YES	YES	YES	YES		
Tracing / Diaphragm / Flushing							
Located in line		Make-up	CW Inlet	CW Outlet	Blowdown		

NOTES:
(1) The presence of solid particles, rubbers, and in general any component that may cause fouling shall also be indicated.
(2) Specify whether gas (G), liquid (L), water vapor (V) or mixed (M)
(3) Approximate density values depending on water quality
(4) Indicate whether the instrument is local (L), panel (P) or local panel (PL)

6.2 Level

Table 6.2. Level instrument list.

INSTRUMENT Nº		LT 1301	LT 1302			
SERVICE		Control	Control			
Design case		High level	Low level			
GENERAL OPERATING DATA						
Nature of upper/lower fluid		Liquid (water)	Liquid (water)			
Corrosive/Toxic compounds (% weight / ppm p) (1)		-	-			
¿Possibility of formation of ...? (2)		NO	NO			
Interface type (3)		L-V (Water-air)	L-V (Water-air)			
Temperature	**ºC**	26	26			
Pressure	**kg/cm² g**	Atmospheric	Atmospheric			
FLUID PROPERTIES						
Density	**kg/m³**	1.174	1.174			
INSTRUMENT CHARACTERISTICS						
Type primary element						
Situation (4)		P	P			
SET POINTS. Normal level:		90%	50%			
High / Very High Alarm	**mm / %**	95%	60%			
Low / Very Low Alarm	**mm / %**	85%	45%			
High / Low Interlock	**mm / %**	Yes	Yes			
Tracing / Diaphragm / Flushing		-	-	**-**	**-**	**-**
Located in line		Cold Water Basin	Cold Water Basin			

NOTES:

(1) The presence of solid particles, rubbers, and in general any component that may cause fouling shall also be indicated.

(2) Indicate services with a tendency to form foam, emulsions, polymers with a tendency to adhere to the vessel walls, to form solid precipitates.

(3) Specify whether liquid-liquid (L-L) or liquid- vapor (L-V)

(4) Indicate whether the instrument is local (L), panel (P) or local panel (PL).

6.3 Pressure

Table 6.3. Pressure instrument list.

INSTRUMENT Nº	SERVICE	DESIGN CASE	GENERAL OPERATING DATA							INSTRUMENT CHARACTERISTICS						
			FLUID	CORROSIVE OR TOXIC COMPONENT (1)	PHASE (2)	TEMP. (ºC)	PRES. (kg/cm² g)			SIT. (3)	SET POINTS (kg/cm2 g)				TRAC. (yes /no) (4)	LOCATED IN LINE
											ALARMS		INTERLOCK			
							MIN	NORM.	MAX.		PAL	PAH	LOW	HIGH		
PIT 1001	Control	OP.	L	-	L	18	0.8	Atm.	2.0	P	0.8	2.0	YES		NO	Make-up
PIT 1002	Control	OP.	L	-	L	26	3.8	4.0	4.5	P	3.8	4.5	YES		NO	Pump Discharge

NOTES:

(1) The presence of solid particles, rubbers, and in general any component that may cause fouling shall also be indicated.

(2) Specify whether gas (G), liquid (L), water vapor (V) or mixed (M)

(3) Indicate whether the instrument is local (L), panel (P) or local panel (PL)

(4) Indicate Tracing / Diaphragm / Flushing

6.4 Temperature

Table 6.4. Temperature instrument list.

INSTRUMENT Nº	SERVICE	DESIGN CASE	GENERAL OPERATING DATA							INSTRUMENT CHARACTERISTICS					
			FLUID	CORROSIVE OR TOXIC COMPONENT (1)	PHASE (2)	TEMP. (ºC)	TEMPERATURE (ºC)			SITUATION (3)	SET POINTS (ºC)				LOCATED IN LINE
											ALARMS		INTERLOCK		
							MIN.	NORM.	MAX.		TAL	TAH	LOW	HIGH	
TIT 1201	Control	OP.	L	-	L	18.0	14.0	18.0	22.0	P	14.0	22.0	-	-	Make-up
TIT 1202	Control	OP.	L	-	L	32.0	28.0	32.0	35.0	P	28.0	35.0	-	-	CW Inlet
TIT 1203	Control	OP.	L	-	L	26.0	23.0	26.0	29.0	P	23.0	29.0	-	-	CW Outlet

NOTES:

(1) The presence of solid particles, rubbers, and in general any component that may cause fouling shall also be indicated.

(2) Specify whether gas (G), liquid (L), water vapor (V) or mixed (M)

(3) Indicate whether the instrument is local (L), panel (P) or local panel (PL)

6.5 Analysers

Table 6.5. Analysers list.

INSTRUMENT Nº		pH IT 1601	pH IT 1603	pH IT 1605	µS IT 1602	µS IT 1604	µS IT 1606	Cl_2 IT 1607		
SERVICE		Control	Control	Control	Control	Control	Control	Control		
Design case		Operation	Operation	Operation	Operation	Operation	Operation	Operation		
GENERAL OPERATING DATA										
Nature of the fluid		L (water)	L (water)	L (water)	L (water)	L (water)	L (water)	L (water)		
Corrosive / Toxic compounds (% weight / ppm p) (1)		No	No	No	No	No	No	No		
Phase (2)		L	L	L	L	L	L	L		
Temperature	**ºC**	18.0	32	26	18	32	26	26		
Pressure	**kg/cm² g**	Atmospheric	4.00	Atmospheric	Atmospheric	4.00	Atmospheric	Atmospheric		
FLUID PROPERTIES (2)										
Property to be analysed		pH	pH	pH	Conductivity	Conductivity	Conductivity	Chlorine		
Normal value		7.8	7.5	7.5	1,800	3,500	3,500	0.50		
Minimum value		7.3	7.0	7.0	1,600	3,000	3,000	0.25		
Maximum value		8.3	8.0	8.0	2,000	4,000	4,000	1.00		
INSTRUMENT CHARACTERISTICS										
Situation (3)		PL	PL	PL	PL	PL	PL	PL		
SET POINTS										
High / Very High Alarm	**%**	110%	110%	110%	110%	110%	110%	110%		
Low / Very Low Alarm	**%**	90%	90%	90%	90%	90%	90%	90%		
Low / High Interlock	**%**	No	No	No	No	No	No	No		
Located in line		Make-up	CW Inlet	CW Outlet	Make-up	CW Inlet	CW Outlet	CW Outlet		

NOTES:

(1) The presence of solid particles, rubbers, and in general any component that may cause fouling shall also be indicated.

(2) Specify whether gas (G), liquid (L), water vapor (V) or mixed (M)

(3) Indicate whether the instrument is local (L), panel (P) or local panel (PL)

7 MSDS

7.1 Sulfuric acid

FICHA DE DATOS DE SEGURIDAD
(de acuerdo con el Reglamento (UE) 2020/878)

1220-ACIDO SULFURICO 98%

Versión 1 **Fecha de emisión: 8/02/2019** **Página 1 de 11**
Versión 15 (sustituye a la versión 14) **Fecha de revisión: 08/09/2022** **Fecha de impresión: 08/09/2022**

SECCIÓN 1: IDENTIFICACIÓN DE LA SUSTANCIA O LA MEZCLA Y DE LA SOCIEDAD O LA EMPRESA.

1.1 Identificador de producto.

Nombre del producto:	ACIDO SULFURICO 98%
Código del producto:	1220
Nombre químico:	ácido sulfúrico al 100 %
N. Indice:	016-020-00-8
N. CAS:	7664-93-9
N. CE:	231-639-5
N. registro:	01-2119458838-20-XXXX

1.2 Usos pertinentes identificados de la sustancia o de la mezcla y usos desaconsejados.

Producto químico para la indústria.
Fabricación de la sustancia o uso como intermedio o como agente de procesamiento químico y extracción.
Uso como reactivo de laboratorio
Agente de decapado de metales.
Industria agroalimentaria.
Ingeniería eléctrica/electrónica.
Fabricación de dióxido de cloro (agente blanqueante en la fabricación de papel).
Baterías.
Producto químico del tratamiento del agua - regulador de pH

Usos desaconsejados:
Usos distintos a los aconsejados.

1.3 Datos del proveedor de la ficha de datos de seguridad.

Empresa:	**QUÍMICA DEL FRANCOLÍ, S.A.**
Dirección:	Pol. Ind. Constantí, C/ Alemania s/n
Población:	43120 - Constantí
Provincia:	Tarragona
Teléfono:	977 520 033
Fax:	977 520 216
E-mail:	quifransa@quifransa.com
Web:	www.quifransa.com

1.4 Teléfono de emergencia: (Disponible 24h)
Servicio de Información Toxicológica (Instituto Nacional de Toxicología y Ciencias Forenses) Teléfono: +34 91 5620420.
Información en español (24h/365 días). Únicamente con la finalidad de proporcionar respuesta sanitaria en caso de urgencia.

SECCIÓN 2: IDENTIFICACIÓN DE LOS PELIGROS.

2.1 Clasificación de la sustancia o de la mezcla.
Según el Reglamento (EU) No 1272/2008:
Skin Corr. 1A : Provoca quemaduras graves en la piel y lesiones oculares graves.

2.2 Elementos de la etiqueta.
Etiquetado conforme al Reglamento (EU) No 1272/2008:
Pictogramas:

FICHA DE DATOS DE SEGURIDAD
(de acuerdo con el Reglamento (UE) 2020/878)

1220-ACIDO SULFURICO 98%

Palabra de advertencia:
Peligro
Indicaciones de peligro:
H314 Provoca quemaduras graves en la piel y lesiones oculares graves.

Consejos de prudencia:
P260 No respirar el polvo/el humo/el gas/la niebla/los vapores/el aerosol.
P264 Lavarse las manos concienzudamente tras la manipulación.
P280 Llevar guantes/ropa de protección/equipo de protección para los ojos/la cara/los oídos/...
P303+P361+P353 EN CASO DE CONTACTO CON LA PIEL (o el pelo): Quitar inmediatamente toda la ropa contaminada. Enjuagar la piel con agua [o ducharse].
P305+P351+P338 EN CASO DE CONTACTO CON LOS OJOS: Enjuagar con agua cuidadosamente durante varios minutos. Quitar las lentes de contacto cuando estén presentes y pueda hacerse con facilidad. Proseguir con el lavado.
P310 Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA/médico/...
P501 Eliminar el contenido/el recipiente de conformidad con la normativa local, regional, nacional o internacional.

2.3 Otros peligros.

La sustancia no es PBT
La sustancia no es mPmB
La sustancia no tiene propiedades de alteración endocrina.

En condiciones de uso normal y en su forma original, el producto no tiene ningún otro efecto negativo para la salud y el medio ambiente.

SECCIÓN 3: COMPOSICIÓN/INFORMACIÓN SOBRE LOS COMPONENTES.

3.1 Sustancias.

Identificadores	Nombre	Concentración	(*)Clasificación - Reglamento 1272/2008	
			Clasificación	Límites de concentración específicos y Estimación de Toxicidad Aguda
N. Indice: 016-020-00-8 N. CAS: 7664-93-9 N. CE: 231-639-5	ácido sulfúrico al 100 %	15 - 100 %	Skin Corr. 1A, H314	Skin Corr. 1A, H314: C ≥ 15 % Skin Irrit. 2, H315: 5 % ≤ C < 15 % Eye Irrit. 2, H319: 5 % ≤ C < 15 %

3.2 Mezclas.
No Aplicable.

SECCIÓN 4: PRIMEROS AUXILIOS.

La información de la composición actualizada del producto ha sido remitida al Servicio de información Toxicológica (Instituto Nacional de Toxicología y Ciencias Forenses). En caso de intoxicación llamar al Servicio de Información Toxicológica:
Tfno (24 horas) 91 562 04 20
4.1 Descripción de los primeros auxilios.
En los casos de duda, o cuando persistan los síntomas de malestar, solicitar atención médica. No administrar nunca nada por vía oral a personas que se encuentren inconscientes.

Inhalación.

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Situar al accidentado al aire libre, mantenerle caliente y en reposo, si la respiración es irregular o se detiene, practicar respiración artificial.

Contacto con los ojos.
Lavar abundantemente los ojos con agua limpia y fresca durante, por lo menos, 10 minutos, tirando hacia arriba de los párpados y buscar asistencia médica. No permita que la persona se frote el ojo afectado.

Contacto con la piel.
Quitar la ropa contaminada. Lavar la piel vigorosamente con agua y jabón o un limpiador de piel adecuado. NUNCA utilizar disolventes o diluyentes. Es recomendable para las personas que dispensan los primeros auxilios el uso de equipos de protección individual (ver sección 8).

Ingestión.
Si accidentalmente se ha ingerido, buscar inmediatamente atención médica. Mantenerle en reposo. NUNCA provocar el vómito.

4.2 Principales síntomas y efectos, agudos y retardados.
Producto Corrosivo, el contacto con los ojos o con la piel puede producir quemaduras, la ingestión o la inhalación puede producir daños internos, en el caso de producirse se requiere asistencia médica inmediata.

4.3 Indicación de toda atención médica y de los tratamientos especiales que deban dispensarse inmediatamente.
Solicite ayuda médica de inmediato. No administrar nunca nada por vía oral a personas que se encuentren inconscientes. No inducir el vómito. Si la persona vomita, despeje las vías respiratorias. Cubra la zona afectada con un apósito estéril seco. Proteja la zona afectada de presión o fricción.

SECCIÓN 5: MEDIDAS DE LUCHA CONTRA INCENDIOS.

El producto NO está clasificado como inflamable, en caso de incendio se deben seguir las medidas expuestas a continuación:

5.1 Medios de extinción.
Medios de extinción apropiados:
Polvo extintor o CO2. En caso de incendios más graves también espuma resistente al alcohol y agua pulverizada.

Medios de extinción no apropiados:
No usar para la extinción chorro directo de agua. En presencia de tensión eléctrica no es aceptable utilizar agua o espuma como medio de extinción.

5.2 Peligros específicos derivados de la sustancia o la mezcla.
Riesgos especiales.
La exposición a los productos de combustión o descomposición puede ser perjudicial para la salud.

5.3 Recomendaciones para el personal de lucha contra incendios.
Refrigerar con agua los tanques, cisternas o recipientes próximos a la fuente de calor o fuego. Tener en cuenta la dirección del viento. Evitar que los productos utilizados en la lucha contra incendio pasen a desagües, alcantarillas o cursos de agua.

Equipo de protección contra incendios.
Según la magnitud del incendio, puede ser necesario el uso de trajes de protección contra el calor, equipo respiratorio autónomo, guantes, gafas protectoras o máscaras faciales y botas.

SECCIÓN 6: MEDIDAS EN CASO DE VERTIDO ACCIDENTAL.

6.1 Precauciones personales, equipo de protección y procedimientos de emergencia.
Para control de exposición y medidas de protección individual, ver sección 8.

6.2 Precauciones relativas al medio ambiente.
Producto no clasificado como peligroso para el medio ambiente, evitar en la medida de lo posible cualquier vertido.

6.3 Métodos y material de contención y de limpieza.
Contener y recoger el vertido con material absorbente inerte (tierra, arena, vermiculita, tierra de diatomeas...) y limpiar la zona inmediatamente con un descontaminante adecuado.

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Depositar los residuos en envases cerrados y adecuados para su eliminación, de conformidad con las normativas locales y nacionales (ver sección 13).

6.4 Referencia a otras secciones.
Para control de exposición y medidas de protección individual, ver sección 8.
Para la eliminación de los residuos, seguir las recomendaciones de la sección 13.

SECCIÓN 7: MANIPULACIÓN Y ALMACENAMIENTO.

7.1 Precauciones para una manipulación segura.
Para la protección personal, ver sección 8.
En la zona de aplicación debe estar prohibido fumar, comer y beber.
Cumplir con la legislación sobre seguridad e higiene en el trabajo.
No emplear nunca presión para vaciar los envases, no son recipientes resistentes a la presión. Conservar el producto en envases de un material idéntico al original.

7.2 Condiciones de almacenamiento seguro, incluidas posibles incompatibilidades.
Almacenar según la legislación local. Observar las indicaciones de la etiqueta. Almacenar los envases entre 5 y 25 ºC, en un lugar seco y bien ventilado, lejos de fuentes de calor y de la luz solar directa. Mantener lejos de puntos de ignición. Mantener lejos de agentes oxidantes y de materiales fuertemente ácidos o alcalinos. No fumar. Evitar la entrada a personas no autorizadas. Una vez abiertos los envases, han de volverse a cerrar cuidadosamente y colocarlos verticalmente para evitar derrames.

El producto no se encuentra afectado por la Directiva 2012/18/UE (SEVESO III).

7.3 Usos específicos finales.
Los usos aconsejados del producto se describen en el epigrafe 1.
Los escenarios de exposición figuran en el anexo , cuando se disponga de ellos y sean aplicables . Véase la información facilitada por el fabricante.

SECCIÓN 8: CONTROLES DE EXPOSICIÓN/PROTECCIÓN INDIVIDUAL.

8.1 Parámetros de control.

Límite de exposición durante el trabajo para:

Nombre	N. CAS	País	Valor límite	ppm	mg/m³
ácido sulfúrico al 100 %	7664-93-9	España [1]	**Ocho horas**		0,05 (niebla - fracción torácica)
			Corto plazo		
		European Union [2]	**Ocho horas**		0,05
			Corto plazo		

[1] Según la lista de Valores Límite Ambientales de Exposición Profesional adoptados por el Instituto Nacional de Seguridad y Salud en el Trabajo (INSST) para el año 2022.
[2] According both Binding Occupational Esposure Limits (BOELVs) and Indicative Occupational Exposure Limits (IOELVs) adopted by Scientific Committee for Occupational Exposure Limits to Chemical Agents (SCOEL).
El producto NO contiene sustancias con Valores Límite Biológicos.
Niveles de concentración DNEL/DMEL:

Nombre	DNEL/DMEL	Tipo	Valor
ácido sulfúrico al 100 % N. CAS: 7664-93-9 N. CE: 231-639-5	DNEL (Trabajadores)	Inhalación, Crónico, Efectos locales	0,05 (mg/m³)

DNEL: Derived No Effect Level, (nivel sin efecto obtenido) nivel de exposición a la sustancia por debajo del cual no se prevén efectos adversos.
DMEL: Derived Minimal Effect Level, nivel de exposición que corresponde a un riesgo bajo, que debe considerarse un riesgo mínimo tolerable.

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FICHA DE DATOS DE SEGURIDAD
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1220-ACIDO SULFURICO 98%

8.2 Controles de la exposición.

Medidas de orden técnico:
Proveer una ventilación adecuada, lo cual puede conseguirse mediante una buena extracción-ventilación local y un buen sistema general de extracción.

Concentración:	**100 %**
Usos:	**Producto químico para la indústria.** **Fabricación de la sustancia o uso como intermedio o como agente de procesamiento químico y extracción.** **Uso como reactivo de laboratorio** **Agente de decapado de metales.** **Industria agroalimentaria.** **Ingeniería eléctrica/electrónica.** **Fabricación de dióxido de cloro (agente blanqueante en la fabricación de papel).** **Baterías.** **Producto químico del tratamiento del agua - regulador de pH**
Protección respiratoria:	
EPI:	Máscara filtrante para la protección contra gases y partículas
Características:	Marcado «CE» Categoría III. La máscara debe tener amplio campo de visión y forma anatómica para ofrecer estanqueidad y hermeticidad.
Normas CEN:	EN 136, EN 140, EN 405
Mantenimiento:	No se debe almacenar en lugares expuestos a temperaturas elevadas y ambientes húmedos antes de su utilización. Se debe controlar especialmente el estado de las válvulas de inhalación y exhalación del adaptador facial.
Observaciones:	Se deberán leer atentamente las instrucciones del fabricante al respecto del uso y mantenimiento del equipo. Se acoplarán al equipo los filtros necesarios en función de las características específicas del riesgo (Partículas y aerosoles: P1-P2-P3, Gases y vapores: A-B-E-K-AX) cambiándose según aconseje el fabricante.
Tipo de filtro necesario:	A2
Protección de las manos:	
EPI:	Guantes no desechables de protección contra productos químicos
Características:	Marcado «CE» Categoría III. Se debe revisar la lista de productos químicos frente a los cuales se ha ensayado el guante.
Normas CEN:	EN 374-1, En 374-2, EN 374-3, EN 420
Mantenimiento:	Deberá establecerse un calendario para la sustitución periódica de los guantes a fin de garantizar que se cambien antes de ser permeados por los contaminantes. La utilización de guantes contaminados puede ser más peligrosa que la falta de utilización, debido a que el contaminante puede irse acumulando en el material componente del guante.
Observaciones:	Se sustituirán siempre que se observen roturas, grietas o deformaciones y cuando la suciedad exterior pueda disminuir su resistencia.

Material:	PVC (Cloruro de polivinilo)	Tiempo de penetración (min.):	> 480	Espesor del material (mm):	0,35

Protección de los ojos:	
EPI:	Gafas de protección con montura integral
Características:	Marcado «CE» Categoría II. Protector de ojos de montura integral para la protección contra salpicaduras de líquidos, polvo, humos, nieblas y vapores.
Normas CEN:	EN 165, EN 166, EN 167, EN 168
Mantenimiento:	La visibilidad a través de los oculares debe ser óptima para lo cual estos elementos se deben limpiar a diario, los protectores deben desinfectarse periódicamente siguiendo las instrucciones del fabricante.
Observaciones:	Indicadores de deterioro pueden ser: coloración amarilla de los oculares, arañazos superficiales en los oculares, rasgaduras, etc.
Protección de la piel:	
EPI:	Ropa de protección contra productos químicos
Características:	Marcado «CE» Categoría III. La ropa debe tener un buen ajuste. Se debe fijar el nivel de protección en función un parámetro de ensayo denominado "Tiempo de paso" (BT. Breakthrough Time) el cual indica el tiempo que el producto químico tarda en atravesar el material.
Normas CEN:	EN 464,EN 340, EN 943-1, EN 943-2, EN ISO 6529, EN ISO 6530, EN 13034

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Mantenimiento:	Se deben seguir las instrucciones de lavado y conservación proporcionadas por el fabricante para garantiza una protección invariable.
Observaciones:	El diseño de la ropa de protección debería facilitar su posicionamiento correcto y su permanencia sin desplazamiento, durante el período de uso previsto, teniendo el cuenta los factores ambientales, junto con los movimientos y posturas que el usuario pueda adoptar durante su actividad.
EPI:	Calzado de seguridad frente a productos químicos y con propiedades antiestáticas
Características:	Marcado «CE» Categoría III. Se debe revisar la lista de productos químicos frente a los cuales es resistente el calzado.
Normas CEN:	EN ISO 13287, EN 13832-1, EN 13832-2, EN 13832-3, EN ISO 20344, EN ISO 20345
Mantenimiento:	Para el correcto mantenimiento de este tipo de calzado de seguridad es imprescindible tener en cuenta las instrucciones especificadas por el fabricante. El calzado se debe reemplazar ante cualquier indicio de deterioro.
Observaciones:	El calzado se debe limpiar regularmente y secarse cuando esté húmedo pero sin colocarse demasiado cerca de una fuente de calor para evitar el cambio brusco de temperatura.

SECCIÓN 9: PROPIEDADES FÍSICAS Y QUÍMICAS.

9.1 Información sobre propiedades físicas y químicas básicas.
Estado físico: Líquido
Color: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Olor: Inodoro. Puede percibirse un olor punzante si el ácido presenta ciertas impurezas.
Umbral olfativo: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Punto de fusión: -1,1< ºC < 3
Punto de congelación: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Punto/Punto inicial/intervalo de ebullición: >=310 ºC
Inflamabilidad: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Límite inferior de explosión: La sustancia es un ácido inorgánico que no contiene grupos químicos asociados a propiedades explosivas.
Límite superior de explosión: La sustancia es un ácido inorgánico que no contiene grupos químicos asociados a propiedades explosivas.
Punto de inflamación: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Temperatura de auto-inflamación: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Temperatura de descomposición: 340 ºC
pH: < 1 a 20ºC
Viscosidad cinemática: 26,9 mPa·s
Solubilidad: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Hidrosolubilidad: Miscible con agua en todas las proporciones con gran liberación de calor
Liposolubilidad: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Coeficiente de reparto (n-octanol/agua)(valor logaritmico): No relevante para sustancias ionizables
Presión de vapor: 0,001 mmHg
Densidad absoluta: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Densidad relativa: 1,83 - 1,85
Densidad de vapor: 3,4 (aire=1)
Características de las partículas: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.

9.2 Otros datos.
Viscosidad: 25 cps (20ºC) (98 % H2SO4)
Propiedades explosivas: La sustancia es un ácido inorgánico que no contiene grupos químicos asociados a propiedades explosivas.
Propiedades comburentes: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Punto de gota: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Centelleo: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
% Sólidos: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.

SECCIÓN 10: ESTABILIDAD Y REACTIVIDAD.

10.1 Reactividad.

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No tiene lugar polimerización peligrosa ni reacciones fugitivas. Descompone a 340ºC dando trióxido de azufre y agua. Es extremadamente reactivo con metales, bases, agentes reductores y muchos otros compuestos orgánicos e inorgánicos.

10.2 Estabilidad química.
Estable bajo las condiciones de manipulación y almacenamiento recomendadas (ver epígrafe 7).
El producto es estable en condiciones normales de presión y temperatura. A temperaturas elevadas existe la posibilidad de descomposición con desprendimiento de gases peligrosos (óxidos de azufre).

10.3 Posibilidad de reacciones peligrosas.
Descomposición con liberación de gases peligrosos (óxidos de azufre). Otros gases peligrosos como cianuro de hidrógeno, sulfuro de hidrógeno y acetileno pueden ser liberados en caso de contacto con agentes químicos como cianuros, sulfuros y carburos respectivamente. El contacto con materia orgánica combustible puede provocar un incendio o explosión. La dilución del ácido con agua genera grandes cantidades de calor, pudiendo llegar al punto de ebullición y provocar salpicaduras. Añadir siempre el ácido sobre el agua, NO AÑADIR NUNCA AGUA SOBRE EL ÁCIDO.

10.4 Condiciones que deben evitarse.
Altas temperaturas, humedad, materiales incompatibles.

10.5 Materiales incompatibles.
Mantener alejado de agentes oxidantes y de materiales fuertemente alcalinos o ácidos, a fin de evitar reacciones exotérmicas. Agua (Precaución: desprendimiento de calor). Oxidantes fuertes, reductores o materia orgánica combustible. Compuestos alcalinos. Metales alcalinos. Amoníaco. Compuestos alcalino-térreos. Soluciones alcalinas. Ácidos. Metales y sus aleaciones. Fósforo. Óxidos de fósforo. Hidruros. Haluros de halógenos. Sales de ácidos oxohalogénicos. Permanganatos. Nitratos. Carburos. Cianuros. Sulfuros. Cloratos. Fulminatos. Disolventes orgánicos. Sustancias inflammables. Acetiluros. Nitrilos.

10.6 Productos de descomposición peligrosos.
Humos/gases tóxicos de óxidos de azufre cuando se calienta hasta descomposición. Puede reaccionar con agua o vapor produciendo humos tóxicos y corrosivos. Reacciona con carbonatos generando dióxido de carbono.

SECCIÓN 11: INFORMACIÓN TOXICOLÓGICA.

11.1 Información sobre las clases de peligro definidas en el Reglamento (CE) nº 1272/2008.
No existen datos disponibles ensayados del producto.
Las salpicaduras en los ojos pueden causar irritación y daños reversibles.

a) toxicidad aguda;
Toxicidad aguda oral:
LD50, rata = 2140 mg/kg (IUCLID)
Toxicidad aguda inhalación:
LC50, rata = 510 mg/m3 , tiempo de exposición: 2 h (IUCLID)

b) corrosión o irritación cutáneas;
Producto clasificado:
Corrosivo cutáneo, Categoría 1A: Provoca quemaduras graves en la piel y lesiones oculares graves.

c) lesiones o irritación ocular graves;
Datos no concluyentes para la clasificación.

d) sensibilización respiratoria o cutánea;
Datos no concluyentes para la clasificación.

e) mutagenicidad en células germinales;
Datos no concluyentes para la clasificación.

f) carcinogenicidad;
Datos no concluyentes para la clasificación.

g) toxicidad para la reproducción;
Datos no concluyentes para la clasificación.

h) toxicidad específica en determinados órganos (STOT) - exposición única;

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Datos no concluyentes para la clasificación.

i) toxicidad específica en determinados órganos (STOT) - exposición repetida;
Datos no concluyentes para la clasificación.

j) peligro de aspiración;
Datos no concluyentes para la clasificación.

11.2 Información relativa a otros peligros.

Propiedades de alteración endocrina.
Este producto no contiene componentes con propiedades de alteración endocrina con efectos sobre la salud humana.
Otros datos.
No existe información disponible sobre otros efectos adversos para la salud.

SECCIÓN 12: INFORMACIÓN ECOLÓGICA.

12.1 Toxicidad.
No se dispone de información relativa a la Ecotoxicidad.

12.2 Persistencia y degradabilidad.
No se dispone de información relativa a la biodegradabilidad.
No se dispone de información relativa a la degradabilidad.
No existe información disponible sobre la persistencia y degradabilidad del producto.

12.3 Potencial de bioacumulación.
Información sobre la bioacumulación.

Nombre	Bioacumulación			
	Log Kow	BCF	NOECs	Nivel
ácido sulfúrico al 100 % N. CAS: 7664-93-9 N. CE: 231-639-5	No relevante para sustancias ionizables	-	-	Muy bajo

12.4 Movilidad en el suelo.
No existe información disponible sobre la movilidad en el suelo.
No se debe permitir que el producto pase a las alcantarillas o a cursos de agua.
Evitar la penetración en el terreno.

12.5 Resultados de la valoración PBT y mPmB.
No existe información disponible sobre la valoración PBT y mPmB del producto.

12.6 Propiedades de alteración endocrina.
Este producto no contiene componentes con propiedades de alteración endocrina sobre el medio ambiente.

12.7 Otros efectos adversos.
No existe información disponible sobre otros efectos adversos para el medio ambiente.

SECCIÓN 13: CONSIDERACIONES RELATIVAS A LA ELIMINACIÓN.

13.1 Métodos para el tratamiento de residuos.
No se permite su vertido en alcantarillas o cursos de agua. Los residuos y envases vacíos deben manipularse y eliminarse de acuerdo con las legislaciones local/nacional vigentes.
Seguir las disposiciones de la Directiva 2008/98/CE respecto a la gestión de residuos.

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SECCIÓN 14: INFORMACIÓN RELATIVA AL TRANSPORTE.

Transportar siguiendo las normas ADR/TPC para el transporte por carretera, las RID por ferrocarril, las IMDG por mar y las ICAO/IATA para transporte aéreo.
Tierra: Transporte por carretera: ADR, Transporte por ferrocarril: RID.
Documentación de transporte: Carta de porte e Instrucciones escritas.
Mar: Transporte por barco: IMDG.
Documentación de transporte: Conocimiento de embarque.
Aire: Transporte en avión: IATA/ICAO.
Documento de transporte: Conocimiento aéreo.

14.1 Número ONU o número ID.
Nº UN: UN1830

14.2 Designación oficial de transporte de las Naciones Unidas.
Descripción:
ADR/RID: UN 1830, ÁCIDO SULFÚRICO, 8, GE II, (E)
IMDG: UN 1830, ÁCIDO SULFÚRICO, 8, GE/E II
ICAO/IATA: UN 1830, ÁCIDO SULFÚRICO, 8, GE II

14.3 Clase(s) de peligro para el transporte.
Clase(s): 8

14.4 Grupo de embalaje.
Grupo de embalaje: II

14.5 Peligros para el medio ambiente.
Contaminante marino: No
Transporte por barco, FEm - Fichas de emergencia (F – Incendio, S – Derrames): F-A,S-B

14.6 Precauciones particulares para los usuarios.
Etiquetas: 8

Número de peligro: 80
ADR cantidad limitada: 1 L
IMDG cantidad limitada: 1 L
ICAO cantidad limitada: 0,5 L

Disposiciones relativas al transporte a granel en ADR: No autorizado el transporte a granel según el ADR.
Actuar según el punto 6.
Grupo de segregación del Código IMDG: 1 Ácidos

14.7 Transporte marítimo a granel con arreglo a los instrumentos de la OMI.
El producto no está afectado por el transporte a granel en buques.

SECCIÓN 15: INFORMACIÓN REGLAMENTARIA.

15.1 Reglamentación y legislación en materia de seguridad, salud y medio ambiente específicas para la sustancia o la mezcla.
El producto no está afectado por el Reglamento (CE) nº 1005/2009 del Parlamento Europeo y del Consejo, de 16 de septiembre de 2009, sobre las sustancias que agotan la capa de ozono.

El producto no se encuentra afectado por la Directiva 2012/18/UE (SEVESO III).

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El producto no está afectado por el Reglamento (UE) No 528/2012 relativo a la comercialización y el uso de los biocidas.
El producto no se encuentra afectado por el procedimiento establecido en el Reglamento (UE) No 649/2012, relativo a la exportación e importación de productos químicos peligrosos.

Información sobre el Anexo I del Reglamento Delegado (UE) 2020/1737 de la Comisión de 14 de julio de 2020 y el Anexo I del Reglamento (CE) nº273/2004 del Parlamento Europeo y del Consejo de 11 de febrero de 2004 sobre precursores de drogas:

N. CAS	Nombre	Categoría
7664-93-9	ácido sulfúrico al ... %	3

Anexo I: Lista de sustancias catalogadas.

Información sobre el Anexo I y Anexo II del Reglamento (UE) 2019/1148 del Parlamento Europeo y del Consejo de 20 de junio de 2019 sobre la comercialización y la utilización de precursores de explosivos:

N. CAS	Nombre	Anexo
7664-93-9	ácido sulfúrico al ... %	I

Anexo I: Precursores de explosivos restringidos.
Anexo II: Precursores de explosivos notificables.

La puesta a disposición, introducción, posesión o utilización de precursores de explosivos restringidos, por los particulares, están sujetas a la restricción establecida en el artículo 5, apartados 1 y 3 del Reglamento (UE) 2019/1148.

Todas las transacciones sospechosas, desapariciones y robos significativos deben notificarse, en un plazo no superior a 24h, al CITCO (Centro de Inteligencia contra el Terrorismo y el Crimen Organizado) Tlf. 91.534.27.66 Email: precursores@interior.es

15.2 Evaluación de la seguridad química.
No se ha llevado a cabo una evaluación de la seguridad química del producto.

SECCIÓN 16: OTRA INFORMACIÓN.

Códigos de clasificación:

Skin Corr. 1A : Corrosivo cutáneo, Categoría 1A

Modificaciones respecto a la versión anterior:

- Cambios en la información del proveedor (SECCIÓN 1.3).
- Modificación de peligros específicos (SECCIÓN 2.3).
- Cambios en la composición del producto (SECCIÓN 3.2).
- Modificación en las medidas de lucha contra incendios (SECCIÓN 5.2).
- Modificaciones en las medidas en caso de vertido accidental (SECCIÓN 6.1).
- Modificación en los valores de las propiedades físico-químicas (SECCIÓN 9).
- Cambio en la clasificación de peligrosidad (SECCIÓN 11.1).
- Añadidos valores información ecológica (SECCIÓN 12.3).
- Modificación de la clasificación ADR/IMDG/ICAO/IATA/RID (SECCIÓN 14).
- Añadidas abreviaturas y acrónimos (SECCIÓN 16).

Clasificación y procedimiento utilizado para determinar la clasificación de las mezclas con arreglo al Reglamento (CE) nº 1272/2008 [CLP]:

Peligros físicos	Conforme a datos obtenidos de los ensayos
Peligros para la salud	Método de cálculo
Peligros para el medio ambiente	Método de cálculo

-Continúa en la página siguiente.-

Se aconseja realizar formación básica con respecto a seguridad e higiene laboral para realizar una correcta manipulación del producto.

Sistema de calificación de riesgo NFPA 704:

Riesgo - Salud: 3 (Peligro extremo)

Inflamabilidad: 0 (No se quema)

Reactividad: 0 (Estable)

Riesgo específico: COR (Corrosivo)

Abreviaturas y acrónimos utilizados:
ADR/RID: Acuerdo europeo sobre el transporte internacional de mercancías peligrosas por carretera.
BCF: Factor de bioconcentración.
CEN: Comité Europeo de Normalización.
DMEL: Derived Minimal Effect Level, nivel de exposición que corresponde a un riesgo bajo, que debe considerarse un riesgo mínimo tolerable.
DNEL: Derived No Effect Level, (nivel sin efecto obtenido) nivel de exposición a la sustancia por debajo del cual no se prevén efectos adversos.
EC50: Concentración efectiva media.
EPI: Equipo de protección personal.
IATA: Asociación Internacional de Transporte Aéreo.
ICAO: Organización de Aviación Civil Internacional.
IMDG: Código Marítimo Internacional de Mercancías Peligrosas.
LC50: Concentración Letal, 50%.
LD50: Dosis Letal, 50%.
NOEC: Concentración sin efecto observado.
RID: Regulación concerniente al transporte internacional de mercancías peligrosas por ferrocarril.

Principales referencias bibliográficas y fuentes de datos:
http://eur-lex.europa.eu/homepage.html
http://echa.europa.eu/
Reglamento (UE) 2020/878.
Reglamento (CE) No 1907/2006.
Reglamento (EU) No 1272/2008.

La información facilitada en esta ficha de Datos de Seguridad ha sido redactada de acuerdo con el REGLAMENTO (UE) 2020/878 DE LA COMISIÓN de 18 de junio de 2020 por el que se modifica el anexo II del Reglamento (CE) n.o 1907/2006 del Parlamento Europeo y del Consejo, relativo al registro, la evaluación, la autorización y la restricción de las sustancias y mezclas químicas (REACH).

La información de esta Ficha de Datos de Seguridad del Producto está basada en los conocimientos actuales y en las leyes vigentes de la CE y nacionales, en cuanto que las condiciones de trabajo de los usuarios están fuera de nuestro conocimiento y control. El producto no debe utilizarse para fines distintos a aquellos que se especifican, sin tener primero una instrucción por escrito, de su manejo. Es siempre responsabilidad del usuario tomar las medidas oportunas con el fin de cumplir con las exigencias establecidas en las legislaciones.

-Fin de la ficha de datos de seguridad.-

7.2 Sodium hypochlorite

FICHA DE DATOS DE SEGURIDAD
(de acuerdo con el Reglamento (UE) 2020/878)

2180-HIPOCLORITO SODICO 150G/L - QUIFRANSA

QUIFRANSA
Química del Francolí, S.A.
Subministrament de productes químics

Versión 1 **Fecha de emisión: 21/09/2018** **Página 1 de 14**
Versión 24 (sustituye a la versión 23) **Fecha de revisión: 02/02/2023** **Fecha de impresión: 17/04/2023**

SECCIÓN 1: IDENTIFICACIÓN DE LA SUSTANCIA O LA MEZCLA Y DE LA SOCIEDAD O LA EMPRESA.

1.1 Identificador de producto.

Nombre del producto: HIPOCLORITO SODICO 150G/L - QUIFRANSA
Código del producto: 2180
UFI: 0KA0-505Q-900K-6TC3

1.2 Usos pertinentes identificados de la sustancia o de la mezcla y usos desaconsejados.

Indústria téxtil
Blanquante doméstico (lejía)
Indústria del papel
Biocida - TP2 - Desinfectantes y alguicidas no destinados a la aplicación directa a personas o animales
Biocida - TP4 - Alimentos y piensos
Biocida - TP5 - Agua potable
Biocida - TP11 - Protectores para líquidos utilizados en sistemas de refrigeración y en procesos industriales

Usos desaconsejados:
Usos distintos a los aconsejados.

1.3 Datos del proveedor de la ficha de datos de seguridad.

Empresa: **QUÍMICA DEL FRANCOLÍ, S.A.**
Dirección: POL. IND. CONSTANTÍ, C/ ALEMANIA S/N
Población: 43120 - CONSTANTÍ
Provincia: (TARRAGONA)
Teléfono: 977 520 033
Fax: 977 520 216
E-mail: quifransa@quifransa.com
Web: www.quifransa.com

1.4 Teléfono de emergencia: (Disponible 24h)
Servicio de Información Toxicológica (Instituto Nacional de Toxicología y Ciencias Forenses) Teléfono: +34 91 5620420.
Información en español (24h/365 días). Únicamente con la finalidad de proporcionar respuesta sanitaria en caso de urgencia.

SECCIÓN 2: IDENTIFICACIÓN DE LOS PELIGROS.

2.1 Clasificación de la sustancia o de la mezcla.
Según el Reglamento (CE) No 1272/2008:
Aquatic Acute 1 : Muy tóxico para los organismos acuáticos.
Aquatic Chronic 2 : Tóxico para los organismos acuáticos, con efectos nocivos duraderos.
Eye Dam. 1 : Provoca lesiones oculares graves.
Skin Corr. 1B : Provoca quemaduras graves en la piel y lesiones oculares graves.
Met. Corr. 1 : Puede ser corrosivo para los metales.

2.2 Elementos de la etiqueta.
Etiquetado conforme al Reglamento (CE) No 1272/2008:
Pictogramas:

Palabra de advertencia:

-Continúa en la página siguiente.-

Peligro

Indicaciones de peligro:

H314	Provoca quemaduras graves en la piel y lesiones oculares graves.
H410	Muy tóxico para los organismos acuáticos, con efectos nocivos duraderos.
H290	Puede ser corrosivo para los metales.

Consejos de prudencia:

P260	No respirar el polvo/el humo/el gas/la niebla/los vapores/el aerosol.
P273	Evitar su liberación al medio ambiente.
P280	Llevar guantes/ropa de protección/equipo de protección para los ojos/la cara/los oídos/...
P303+P361+P353	EN CASO DE CONTACTO CON LA PIEL (o el pelo): Quitar inmediatamente toda la ropa contaminada. Enjuagar la piel con agua [o ducharse].
P305+P351+P338	EN CASO DE CONTACTO CON LOS OJOS: Enjuagar con agua cuidadosamente durante varios minutos. Quitar las lentes de contacto cuando estén presentes y pueda hacerse con facilidad. Proseguir con el lavado.
P310	Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA/médico/...
P390	Absorber el vertido para que no dañe otros materiales.

Indicaciones de peligro suplementarias:

EUH031	En contacto con ácidos libera gases tóxicos.

Contiene:
hipoclorito de sodio, solución con ... % de Cl activo

Sustancias activas:
hipoclorito de sodio, solución con ... % de Cl activo, 13%;

2.3 Otros peligros.

La mezcla no contiene sustancias clasificadas como PBT (Persistente, Bioacumulable y Tóxica).
La mezcla no contiene sustancias clasificadas como mPmB (muy Persistente y muy Bioacumulable).
La mezcla no contiene sustancias con propiedades de alteración endocrina.

En condiciones de uso normal y en su forma original, el producto no tiene ningún otro efecto negativo para la salud y el medio ambiente.

SECCIÓN 3: COMPOSICIÓN/INFORMACIÓN SOBRE LOS COMPONENTES.

3.1 Sustancias.
No Aplicable.

3.2 Mezclas.
Sustancias que representan un peligro para la salud o el medio ambiente de acuerdo con el Reglamento (CE) No. 1272/2008, tienen asignado un límite de exposición comunitario en el lugar de trabajo, están clasificadas como PBT/mPmB o incluidas en la Lista de Candidatos:

Identificadores	Nombre	Concentración	(*)Clasificación - Reglamento 1272/2008	
			Clasificación	Límites de concentración específicos y Estimación de Toxicidad Aguda

-Continúa en la página siguiente.-

N. Indice: 017-011-00-1 N. CAS: 7681-52-9 N. CE: 231-668-3 N. registro: 01-2119488154-34-XXXX	hipoclorito de sodio, solución con ... % de Cl activo	5 - 20 %	Aquatic Acute 1, H400 (M=10) - Aquatic Chronic 1, H410 (M=1) - Eye Dam. 1, H318 - Met. Corr. 1, H290 - STOT SE 3, H335 - Skin Corr. 1B, H314	EUH031: C ≥ 5 %
N. Indice: 011-005-00-2 N. CAS: 497-19-8 N. CE: 207-838-8 N. registro: 01-2119485498-19-XXXX	carbonato de sodio	1 - 10 %	Eye Irrit. 2, H319	-
N. Indice: 011-002-00-6 N. CAS: 1310-73-2 N. CE: 215-185-5 N. registro: 01-2119457892-27-XXXX	[2] hidróxido de sodio, sosa cáustica	0.5 - 2 %	Eye Dam. 1, H318 - Met. Corr. 1, H290 - Skin Corr. 1A, H314	Skin Corr. 1A, H314: C ≥ 5 % Skin Corr. 1B, H314: 2 % ≤ C < 5 % Skin Irrit. 2, H315: 0,5 % ≤ C < 2 % Eye Irrit. 2, H319: 0,5 % ≤ C < 2 %

(*) *El texto completo de las frases H se detalla en la sección 16 de esta Ficha de Seguridad.*
[2] Sustancia con límite nacional de exposición en el lugar de trabajo (ver sección 8.1).

SECCIÓN 4: PRIMEROS AUXILIOS.

La información de la composición actualizada del producto ha sido remitida al Servicio de información Toxicológica (Instituto Nacional de Toxicología y Ciencias Forenses). En caso de intoxicación llamar al Servicio de Información Toxicológica:
Tfno (24 horas) 91 562 04 20

4.1 Descripción de los primeros auxilios.
En los casos de duda, o cuando persistan los síntomas de malestar, solicitar atención médica. No administrar nunca nada por vía oral a personas que se encuentren inconscientes.

Inhalación.
Situar al accidentado al aire libre, mantenerle caliente y en reposo, si la respiración es irregular o se detiene, practicar respiración artificial.

Contacto con los ojos.
Lavar abundantemente los ojos con agua limpia y fresca durante, por lo menos, 10 minutos, tirando hacia arriba de los párpados y buscar asistencia médica. No permita que la persona se frote el ojo afectado.

Contacto con la piel.
Quitar la ropa contaminada. Lavar la piel vigorosamente con agua y jabón o un limpiador de piel adecuado. NUNCA utilizar disolventes o diluyentes. Es recomendable para las personas que dispensan los primeros auxilios el uso de equipos de protección individual (ver sección 8).

Ingestión.
Si accidentalmente se ha ingerido, buscar inmediatamente atención médica. Mantenerle en reposo. NUNCA provocar el vómito.

4.2 Principales síntomas y efectos, agudos y retardados.
Producto Corrosivo, el contacto con los ojos o con la piel puede producir quemaduras, la ingestión o la inhalación puede producir daños internos, en el caso de producirse se requiere asistencia médica inmediata.
El contacto con los ojos puede producir daños irreversibles.

-Continúa en la página siguiente.-

4.3 Indicación de toda atención médica y de los tratamientos especiales que deban dispensarse inmediatamente.
Solicite ayuda médica de inmediato. No administrar nunca nada por vía oral a personas que se encuentren inconscientes. No inducir el vómito. Si la persona vomita, despeje las vías respiratorias. Cubra la zona afectada con un apósito estéril seco. Proteja la zona afectada de presión o fricción.

SECCIÓN 5: MEDIDAS DE LUCHA CONTRA INCENDIOS.

El producto NO está clasificado como inflamable, en caso de incendio se deben seguir las medidas expuestas a continuación:

5.1 Medios de extinción.
Medios de extinción apropiados:
Polvo extintor o CO2. En caso de incendios más graves también espuma resistente al alcohol y agua pulverizada.

Medios de extinción no apropiados:
No usar para la extinción chorro directo de agua. En presencia de tensión eléctrica no es aceptable utilizar agua o espuma como medio de extinción.

5.2 Peligros específicos derivados de la sustancia o la mezcla.
Riesgos especiales.
La exposición a los productos de combustión o descomposición puede ser perjudicial para la salud.

5.3 Recomendaciones para el personal de lucha contra incendios.
Refrigerar con agua los tanques, cisternas o recipientes próximos a la fuente de calor o fuego. Tener en cuenta la dirección del viento. Evitar que los productos utilizados en la lucha contra incendio pasen a desagües, alcantarillas o cursos de agua. Los restos de producto y medios de extinción pueden contaminar el medio ambiente acuático.

Equipo de protección contra incendios.
Según la magnitud del incendio, puede ser necesario el uso de trajes de protección contra el calor, equipo respiratorio autónomo, guantes, gafas protectoras o máscaras faciales y botas.

SECCIÓN 6: MEDIDAS EN CASO DE VERTIDO ACCIDENTAL.

6.1 Precauciones personales, equipo de protección y procedimientos de emergencia.
Para control de exposición y medidas de protección individual, ver sección 8.

6.2 Precauciones relativas al medio ambiente.
Producto peligroso para el medio ambiente, en caso de producirse grandes vertidos o si el producto contamina lagos, ríos o alcantarillas, informar a las autoridades competentes, según la legislación local. Evitar la contaminación de desagües, aguas superficiales o subterráneas, así como del suelo.

6.3 Métodos y material de contención y de limpieza.
Contener y recoger el vertido con material absorbente inerte (tierra, arena, vermiculita, tierra de diatomeas...) y limpiar la zona inmediatamente con un descontaminante adecuado.
Depositar los residuos en envases cerrados y adecuados para su eliminación, de conformidad con las normativas locales y nacionales (ver sección 13).

6.4 Referencia a otras secciones.
Para control de exposición y medidas de protección individual, ver sección 8.
Para la eliminación de los residuos, seguir las recomendaciones de la sección 13.

SECCIÓN 7: MANIPULACIÓN Y ALMACENAMIENTO.

7.1 Precauciones para una manipulación segura.
Para la protección personal, ver sección 8.
En la zona de aplicación debe estar prohibido fumar, comer y beber.
Cumplir con la legislación sobre seguridad e higiene en el trabajo.

-Continúa en la página siguiente.-

No emplear nunca presión para vaciar los envases, no son recipientes resistentes a la presión. Conservar el producto en envases de un material idéntico al original.

7.2 Condiciones de almacenamiento seguro, incluidas posibles incompatibilidades.
Almacenar según la legislación local. Observar las indicaciones de la etiqueta. Almacenar los envases entre 5 y 25 ºC, en un lugar seco y bien ventilado, lejos de fuentes de calor y de la luz solar directa. Mantener lejos de puntos de ignición. Mantener lejos de agentes oxidantes y de materiales fuertemente ácidos o alcalinos. No fumar. Evitar la entrada a personas no autorizadas. Una vez abiertos los envases, han de volverse a cerrar cuidadosamente y colocarlos verticalmente para evitar derrames.

Clasificación y cantidad umbral de almacenaje de acuerdo con el Anexo I de la Directiva 2012/18/UE (SEVESO III):

		Cantidad umbral (toneladas) a efectos de aplicación de los	
Código	**Descripción**	**requisitos de nivel inferior**	**requisitos de nivel superior**
E1	PELIGROS PARA EL MEDIOAMBIENTE - Peligroso para el medio ambiente acuático en las categorías aguda 1 o crónica 1	100	200
E2	PELIGROS PARA EL MEDIOAMBIENTE - Peligroso para el medio ambiente acuático en la categoría crónica 2	200	500

7.3 Usos específicos finales.
Los usos aconsejados del producto se describen en el epigrafe 1.
Los escenarios de exposición figuran en el anexo , cuando se disponga de ellos y sean aplicables . Véase la información facilitada por el fabricante.

SECCIÓN 8: CONTROLES DE EXPOSICIÓN/PROTECCIÓN INDIVIDUAL.

8.1 Parámetros de control.

Límite de exposición durante el trabajo para:

Nombre	N. CAS	País	Valor límite	ppm	mg/m³
hidróxido de sodio, sosa cáustica	1310-73-2	España [1]	**Ocho horas**		
			Corto plazo		2

[1] Según la lista de Valores Límite Ambientales de Exposición Profesional adoptados por el Instituto Nacional de Seguridad y Salud en el Trabajo (INSST) para el año 2022.
El producto NO contiene sustancias con Valores Límite Biológicos.
Niveles de concentración DNEL/DMEL:

Nombre	DNEL/DMEL	Tipo	Valor
hidróxido de sodio, sosa cáustica N. CAS: 1310-73-2 N. CE: 215-185-5	DNEL (Trabajadores)	Inhalación, Crónico, Efectos locales	1 (mg/m³)
	DNEL (Consumidores)	Inhalación, Crónico, Efectos locales	1 (mg/m³)

DNEL: Derived No Effect Level, (nivel sin efecto obtenido) nivel de exposición a la sustancia por debajo del cual no se prevén efectos adversos.
DMEL: Derived Minimal Effect Level, nivel de exposición que corresponde a un riesgo bajo, que debe considerarse un riesgo mínimo tolerable.

Niveles de concentración PNEC:

Nombre	Detalles	Valor
hipoclorito de sodio, solución con ... % de Cl activo N. CAS: 7681-52-9 N. CE: 231-668-3	Agua dulce	0,21 (µg/L)
	Agua marina	0,042 (µg/L)
	agua (intermittent releases)	0,26 (µg/L)
	Planta de tratamiento de aguas residuales	0,03 (mg/L)
	oral	11,1 (mg/kg food)

-Continúa en la página siguiente.-

PNEC: Predicted No Effect Concentration, (concentración prevista sin efecto) concentración de la sustancia por debajo de la cual no se esperan efectos negativos en el comportamiento medioambiental.

8.2 Controles de la exposición.

Medidas de orden técnico:
Proveer una ventilación adecuada, lo cual puede conseguirse mediante una buena extracción-ventilación local y un buen sistema general de extracción.

Concentración:	**100 %**
Usos:	**Indústria téxtil** **Blanquante doméstico (lejía)** **Indústria del papel** **Biocida - TP2 - Desinfectantes y alguicidas no destinados a la aplicación directa a personas o animales** **Biocida - TP4 - Alimentos y piensos** **Biocida - TP5 - Agua potable** **Biocida - TP11 - Protectores para líquidos utilizados en sistemas de refrigeración y en procesos industriales**
Protección respiratoria:	
EPI:	Máscara filtrante para la protección contra gases y partículas
Características:	Marcado «CE» Categoría III. La máscara debe tener amplio campo de visión y forma anatómica para ofrecer estanqueidad y hermeticidad. 
Normas CEN:	EN 136, EN 140, EN 405
Mantenimiento:	No se debe almacenar en lugares expuestos a temperaturas elevadas y ambientes húmedos antes de su utilización. Se debe controlar especialmente el estado de las válvulas de inhalación y exhalación del adaptador facial.
Observaciones:	Se deberán leer atentamente las instrucciones del fabricante al respecto del uso y mantenimiento del equipo. Se acoplarán al equipo los filtros necesarios en función de las características específicas del riesgo (Partículas y aerosoles: P1-P2-P3, Gases y vapores: A-B-E-K-AX) cambiándose según aconseje el fabricante.
Tipo de filtro necesario:	A2
Protección de las manos:	
EPI:	Guantes no desechables de protección contra productos químicos
Características:	Marcado «CE» Categoría III. Se debe revisar la lista de productos químicos frente a los cuales se ha ensayado el guante. 
Normas CEN:	EN 374-1, En 374-2, EN 374-3, EN 420
Mantenimiento:	Deberá establecerse un calendario para la sustitución periódica de los guantes a fin de garantizar que se cambien antes de ser permeados por los contaminantes. La utilización de guantes contaminados puede ser más peligrosa que la falta de utilización, debido a que el contaminante puede irse acumulando en el material componente del guante.
Observaciones:	Se sustituirán siempre que se observen roturas, grietas o deformaciones y cuando la suciedad exterior pueda disminuir su resistencia.

Material:	PVC (Cloruro de polivinilo)	Tiempo de penetración (min.):	> 480	Espesor del material (mm):	0,35

Protección de los ojos:	
EPI:	Gafas de protección con montura integral
Características:	Marcado «CE» Categoría II. Protector de ojos de montura integral para la protección contra salpicaduras de líquidos, polvo, humos, nieblas y vapores. 
Normas CEN:	EN 165, EN 166, EN 167, EN 168
Mantenimiento:	La visibilidad a través de los oculares debe ser óptima para lo cual estos elementos se deben limpiar a diario, los protectores deben desinfectarse periódicamente siguiendo las instrucciones del fabricante.
Observaciones:	Indicadores de deterioro pueden ser: coloración amarilla de los oculares, arañazos superficiales en los oculares, rasgaduras, etc.
Protección de la piel:	
EPI:	Ropa de protección contra productos químicos
Características:	Marcado «CE» Categoría III. La ropa debe tener un buen ajuste. Se debe fijar el nivel de protección en función un parámetro de ensayo denominado "Tiempo de paso" (BT. Breakthrough Time) el cual indica el tiempo que el producto químico tarda en atravesar el material. 

-Continúa en la página siguiente.-

Normas CEN:	EN 464,EN 340, EN 943-1, EN 943-2, EN ISO 6529, EN ISO 6530, EN 13034
Mantenimiento:	Se deben seguir las instrucciones de lavado y conservación proporcionadas por el fabricante para garantiza una protección invariable.
Observaciones:	El diseño de la ropa de protección debería facilitar su posicionamiento correcto y su permanencia sin desplazamiento, durante el período de uso previsto, teniendo el cuenta los factores ambientales, junto con los movimientos y posturas que el usuario pueda adoptar durante su actividad.
EPI:	Calzado de seguridad frente a productos químicos y con propiedades antiestáticas
Características:	Marcado «CE» Categoría III. Se debe revisar la lista de productos químicos frente a los cuales es resistente el calzado.
Normas CEN:	EN ISO 13287, EN 13832-1, EN 13832-2, EN 13832-3, EN ISO 20344, EN ISO 20345
Mantenimiento:	Para el correcto mantenimiento de este tipo de calzado de seguridad es imprescindible tener en cuenta las instrucciones especificadas por el fabricante. El calzado se debe reemplazar ante cualquier indicio de deterioro.
Observaciones:	El calzado se debe limpiar regularmente y secarse cuando esté húmedo pero sin colocarse demasiado cerca de una fuente de calor para evitar el cambio brusco de temperatura.

SECCIÓN 9: PROPIEDADES FÍSICAS Y QUÍMICAS.

9.1 Información sobre propiedades físicas y químicas básicas.
Estado físico: Líquido
Color: Amarillento
Olor: Picante, recuerda a la del cloro
Umbral olfativo: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Punto de fusión: -20.6 ºC
Punto de congelación: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Punto/Punto inicial/intervalo de ebullición: 101 ºC (Estimación en base a las indicaciones del Reglamento (CE) Nº1272/2008)
Inflamabilidad: No aplicable
Límite inferior de explosión: No disponible
Límite superior de explosión: No disponible
Punto de inflamación: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Temperatura de auto-inflamación: No es necesario llevar a cabo el estudio para líquidos no inflamables en aire (no se observa punto de inflamación hasta los 111 ºC)
Temperatura de descomposición: Mantener por debajo 30ºC
pH: 12 (13%)
Viscosidad cinemática: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Solubilidad: De acuerdo con el Reglamento no es necesario realizar el ensayo de solubilidad y estabilidad en otros disolventes
Hidrosolubilidad: Completamente miscible en agua. Valor calculado: 1e+006 mg/L a 25 °C (WSKOW v1.41)
Liposolubilidad: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Coeficiente de reparto (n-octanol/agua)(valor logaritmico): -3,42 a 20ºC (calculado)
Presión de vapor: 2.5 kPa a 20 °C (hipoclorito de sodio)
Densidad absoluta: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Densidad relativa: 1,220-1,270
Densidad de vapor: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.
Características de las partículas: No aplicable/No disponible debido a la naturaleza/las propiedades del producto.

9.2 Otros datos.
Información relativa a las clases de peligro físico
Explosivos:
Propiedades explosivas: La sustancia no contiene grupos químicos asociados a propiedades explosivas.
Líquidos comburentes:
Propiedades comburentes: No tiene propiedades comburentes (solución 25.3 %)

Otras caracteristicas de seguridad
Viscosidad: 5cP (15ºC)

SECCIÓN 10: ESTABILIDAD Y REACTIVIDAD.

-Continúa en la página siguiente.-

10.1 Reactividad.
La sustancia no presenta riesgos adicionales de reactividad de los que figuran en el siguiente subtítulo.

10.2 Estabilidad química.
La sustancia es estable en condiciones ambientales normales y en condiciones previsibles de temperatura y presión durante su almacenamiento y manipulación.
Se descompone a partir de 35 - 40ºC ºC

10.3 Posibilidad de reacciones peligrosas.
Puede ser corrosivo para los metales.
Puede producirse una neutralización en contacto con ácidos.

10.4 Condiciones que deben evitarse.
Evitar las siguientes condiciones:
- Alta temperatura, luz solar directa.
- Evitar el contacto con ácidos.

10.5 Materiales incompatibles.
Evitar los siguientes materiales: No mezclar nunca con ácidos, compuestos ácidos, productos de limpieza de base acídica, productos que contengan amonio, productos orgánicos, metales (cobre, níquel, cobalto, hierro), peróxido de hidrógeno, agentes reductores.

10.6 Productos de descomposición peligrosos.
Dependiendo de las condiciones de uso, pueden generarse los siguientes productos:
Con ácidos, productos orgánicos, compuestos de amonio, reductores desprendimiento de cloro gas (gas tóxico).
En contacto con metales, peróxido de hidrógeno y por efecto de calor, luz se descompone desprendiendo gases que pueden originar un aumento de presión en el recipiente y provocar una ruptura del mismo.

SECCIÓN 11: INFORMACIÓN TOXICOLÓGICA.

11.1 Información sobre las clases de peligro definidas en el Reglamento (CE) nº 1272/2008.
Las salpicaduras en los ojos pueden causar irritación y daños reversibles.

Información Toxicológica de las sustancias presentes en la composición.

Nombre	Toxicidad aguda			
	Tipo	Ensayo	Especie	Valor
hipoclorito de sodio, solución con ... % de Cl activo N. CAS: 7681-52-9 N. CE: 231-668-3	Oral	LD0 LD50 LD50	Rata Rata Ratón	626 mg/kg bw 1100 mg/kg bw 880 mg/kg
	Cutánea	LD50	Conejo	>10000 mg/kg bw
	Inhalación	LC50	Rata	>10.5 mg/L air (1 h)
hidróxido de sodio, sosa cáustica N. CAS: 1310-73-2 N. CE: 215-185-5	Oral	LD50	Conejo	325 mg/kg bw [1] [1] Naunyn-Schmiedeberg's (1937), Archiv für experimentielle|Pathologie und Pharmakologie (Berlin, Germany), 184,|587-604
	Cutánea			
	Inhalación			

a) toxicidad aguda;
Datos no concluyentes para la clasificación.

b) corrosión o irritación cutáneas;
Producto clasificado:

-Continúa en la página siguiente.-

Corrosivo cutáneo, Categoría 1B: Provoca quemaduras graves en la piel y lesiones oculares graves.

c) lesiones o irritación ocular graves;
Datos no concluyentes para la clasificación.

d) sensibilización respiratoria o cutánea;
Datos no concluyentes para la clasificación.

e) mutagenicidad en células germinales;
Datos no concluyentes para la clasificación.

f) carcinogenicidad;
Datos no concluyentes para la clasificación.

g) toxicidad para la reproducción;
Datos no concluyentes para la clasificación.

h) toxicidad específica en determinados órganos (STOT) - exposición única;
Datos no concluyentes para la clasificación.

i) toxicidad específica en determinados órganos (STOT) - exposición repetida;
Datos no concluyentes para la clasificación.

j) peligro de aspiración;
Datos no concluyentes para la clasificación.

11.2 Información relativa a otros peligros.

Propiedades de alteración endocrina.
Este producto no contiene componentes con propiedades de alteración endocrina con efectos sobre la salud humana.
Otros datos.
No existe información disponible sobre otros efectos adversos para la salud.

SECCIÓN 12: INFORMACIÓN ECOLÓGICA.

12.1 Toxicidad.

Nombre	Ecotoxicidad			
	Tipo	Ensayo	Especie	Valor
hipoclorito de sodio, solución con ... % de Cl activo N. CAS: 7681-52-9 N. CE: 231-668-3	Peces	LC50 LC50 LC50	Coho salmon Chinook salmon Oncorhynchus mykiss	0.032 mg TRO /L (96 h) > 0.038 < 0.065 mg TRO/L (96 h) >1.65 <2.87 mg/L (72 h)
	Invertebrados acuáticos	EC50 LC50	Dafnia magna Baetis harrisoni	141 µg/L (48 h) 11.2 µg/L (24 h)
	Plantas acuáticas	EC50	Myriophyllum spicatum	>0.1<0.4 mg/L (96 h)
hidróxido de sodio, sosa cáustica	Peces	Minimal Lethal Concentration	Notropis sp.	100 mg/L (120 h) [1]
		[1] Van Horn et al. (1949), Effects of Kraft Mill Wastes,|American Fisheries Society		
	Invertebrados acuáticos	LC50	Ophryotrocha diadema	33 mg/L (48 h) [1]

-Continúa en la página siguiente.-

		[1] Parker JG (1984), Wat Res, 18, 865-868
N. CAS: 1310-73-2 N. CE: 215-185-5	Plantas acuáticas	

12.2 Persistencia y degradabilidad.
No se dispone de información relativa a la biodegradabilidad de las sustancias presentes.
No se dispone de información relativa a la degradabilidad de las sustancias presentes.
No existe información disponible sobre la persistencia y degradabilidad del producto.

12.3 Potencial de bioacumulación.
Información sobre la bioacumulación de las sustancias presentes.

Nombre	Bioacumulación			
	Log Kow	BCF	NOECs	Nivel
hipoclorito de sodio, solución con ... % de Cl activo N. CAS: 7681-52-9 N. CE: 231-668-3	3,42	-	50 µg/L	Moderado

12.4 Movilidad en el suelo.
No existe información disponible sobre la movilidad en el suelo.
No se debe permitir que el producto pase a las alcantarillas o a cursos de agua.
Evitar la penetración en el terreno.

12.5 Resultados de la valoración PBT y mPmB.
No existe información disponible sobre la valoración PBT y mPmB del producto.

12.6 Propiedades de alteración endocrina.
Este producto no contiene componentes con propiedades de alteración endocrina sobre el medio ambiente.

12.7 Otros efectos adversos.
No existe información disponible sobre otros efectos adversos para el medio ambiente.

SECCIÓN 13: CONSIDERACIONES RELATIVAS A LA ELIMINACIÓN.

13.1 Métodos para el tratamiento de residuos.
No se permite su vertido en alcantarillas o cursos de agua. Los residuos y envases vacíos deben manipularse y eliminarse de acuerdo con las legislaciones local/nacional vigentes.
Seguir las disposiciones de la Directiva 2008/98/CE respecto a la gestión de residuos.

SECCIÓN 14: INFORMACIÓN RELATIVA AL TRANSPORTE.

Transportar siguiendo las normas ADR/TPC para el transporte por carretera, las RID por ferrocarril, las IMDG por mar y las ICAO/IATA para transporte aéreo.
Tierra: Transporte por carretera: ADR, Transporte por ferrocarril: RID.
Documentación de transporte: Carta de porte e Instrucciones escritas.
Mar: Transporte por barco: IMDG.
Documentación de transporte: Conocimiento de embarque.
Aire: Transporte en avión: IATA/ICAO.
Documento de transporte: Conocimiento aéreo.

14.1 Número ONU o número ID.

-Continúa en la página siguiente.-

Nº UN: UN1791

14.2 Designación oficial de transporte de las Naciones Unidas.
Descripción:
ADR/RID: UN 1791, HIPOCLORITOS EN SOLUCIÓN, 8, GE II, (E)
IMDG: UN 1791, HIPOCLORITOS EN SOLUCIÓN, 8, GE/E II, CONTAMINANTE DEL MAR
ICAO/IATA: UN 1791, HIPOCLORITOS EN SOLUCIÓN, 8, GE II

14.3 Clase(s) de peligro para el transporte.
Clase(s): 8

14.4 Grupo de embalaje.
Grupo de embalaje: II

14.5 Peligros para el medio ambiente.
Contaminante marino: Si

Peligroso para el medio ambiente
Transporte por barco, FEm - Fichas de emergencia (F – Incendio, S – Derrames): F-A,S-B

14.6 Precauciones particulares para los usuarios.
Etiquetas: 8

Número de peligro: 80
ADR cantidad limitada: 1 L
IMDG cantidad limitada: 1 L
ICAO cantidad limitada: 0,5 L

Disposiciones relativas al transporte a granel en ADR: No autorizado el transporte a granel según el ADR.
Actuar según el punto 6.
Grupo de segregación del Código IMDG: 8 Hipocloritos

14.7 Transporte marítimo a granel con arreglo a los instrumentos de la OMI.
El producto no está afectado por el transporte a granel en buques.

SECCIÓN 15: INFORMACIÓN REGLAMENTARIA.

15.1 Reglamentación y legislación en materia de seguridad, salud y medio ambiente específicas para la sustancia o la mezcla.
El producto no está afectado por el Reglamento (CE) nº 1005/2009 del Parlamento Europeo y del Consejo, de 16 de septiembre de 2009, sobre las sustancias que agotan la capa de ozono.

Clasificación del producto de acuerdo con el Anexo I de la Directiva 2012/18/UE (SEVESO III): E1,E2

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FICHA DE DATOS DE SEGURIDAD
(de acuerdo con el Reglamento (UE) 2020/878)

2180-HIPOCLORITO SODICO 150G/L - QUIFRANSA

Química del Francolí, S.A.
Subministrament de productes químics

Información relacionada con el Reglamento (UE) No 528/2012 relativo a la comercialización y el uso de los biocidas:

Tipo de producto	Grupo
Protectores para líquidos utilizados en sistemas de refrigeración y en procesos industriales	Conservantes
Desinfectantes y alguicidas no destinados a la aplicación directa a personas o animales	Desinfectantes
Alimentos y piensos	Desinfectantes
Agua potable	Desinfectantes

Sustancias activas	Concentración %
hipoclorito de sodio, solución con ... % de Cl activo N. CAS: 7681-52-9 N. CE: 231-668-3	13

El producto no se encuentra afectado por el procedimiento establecido en el Reglamento (UE) No 649/2012, relativo a la exportación e importación de productos químicos peligrosos.

Información sobre el Anexo I y Anexo II del Reglamento (UE) 2019/1148 del Parlamento Europeo y del Consejo de 20 de junio de 2019 sobre la comercialización y la utilización de precursores de explosivos:

N. CAS	Nombre	Anexo
7775-09-9	clorato de sodio	I

Anexo I: Precursores de explosivos restringidos.
Anexo II: Precursores de explosivos notificables.

Todas las transacciones sospechosas, desapariciones y robos significativos deben notificarse, en un plazo no superior a 24h, al CITCO (Centro de Inteligencia contra el Terrorismo y el Crimen Organizado) Tlf. 91.534.27.66 Email: precursores@interior.es

15.2 Evaluación de la seguridad química.
No se ha llevado a cabo una evaluación de la seguridad química del producto.
Se dispone de Escenario de Exposición del producto.

SECCIÓN 16: OTRA INFORMACIÓN.

Texto completo de las frases H que aparecen en la sección 3:

EUH031	En contacto con ácidos libera gases tóxicos.
H290	Puede ser corrosivo para los metales.
H314	Provoca quemaduras graves en la piel y lesiones oculares graves.
H315	Provoca irritación cutánea.
H318	Provoca lesiones oculares graves.
H319	Provoca irritación ocular grave.
H335	Puede irritar las vías respiratorias.
H400	Muy tóxico para los organismos acuáticos.
H410	Muy tóxico para los organismos acuáticos, con efectos nocivos duraderos.

Códigos de clasificación:

Aquatic Acute 1 : Toxicidad aguda para el medio ambiente acuático, Categoría 1
Aquatic Chronic 1 : Efectos crónicos para el medio ambiente acuático, Categoría 1
Aquatic Chronic 2 : Efectos crónicos para el medio ambiente acuático, Categoría 2
Eye Dam. 1 : Lesión ocular grave, Categoría 1
Eye Irrit. 2 : Irritación ocular, Categoría 2
Met. Corr. 1 : Materia corrosiva para los metales
STOT SE 3 : Toxicidad en determinados órganos tras exposición única, Categoría 3
Skin Corr. 1A : Corrosivo cutáneo, Categoría 1A
Skin Corr. 1B : Corrosivo cutáneo, Categoría 1B

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FICHA DE DATOS DE SEGURIDAD
(de acuerdo con el Reglamento (UE) 2020/878)

2180-HIPOCLORITO SODICO 150G/L - QUIFRANSA

Química del Francolí, S.A.
Subministrament de productes químics

Modificaciones respecto a la versión anterior:

- Modificación en los valores de las propiedades físico-químicas (SECCIÓN 9).

Clasificación y procedimiento utilizado para determinar la clasificación de las mezclas con arreglo al Reglamento (CE) nº 1272/2008 [CLP]:

Peligros físicos	Conforme a datos obtenidos de los ensayos
Peligros para la salud	Método de cálculo
Peligros para el medio ambiente	Método de cálculo

Se aconseja realizar formación básica con respecto a seguridad e higiene laboral para realizar una correcta manipulación del producto.

Sistema de calificación de riesgo NFPA 704:

Riesgo - Salud: 3 (Peligro extremo)

Inflamabilidad: 0 (No se quema)

Reactividad: 1 (Inestable si se calienta)

Riesgo específico: COR (Corrosivo)

Se dispone de Escenario de Exposición del producto.

Abreviaturas y acrónimos utilizados:

ADR/RID:	Acuerdo europeo sobre el transporte internacional de mercancías peligrosas por carretera.
BCF:	Factor de bioconcentración.
CEN:	Comité Europeo de Normalización.
DMEL:	Derived Minimal Effect Level, nivel de exposición que corresponde a un riesgo bajo, que debe considerarse un riesgo mínimo tolerable.
DNEL:	Derived No Effect Level, (nivel sin efecto obtenido) nivel de exposición a la sustancia por debajo del cual no se prevén efectos adversos.
EC50:	Concentración efectiva media.
EPI:	Equipo de protección personal.
IATA:	Asociación Internacional de Transporte Aéreo.
ICAO:	Organización de Aviación Civil Internacional.
IMDG:	Código Marítimo Internacional de Mercancías Peligrosas.
LC50:	Concentración Letal, 50%.
LD50:	Dosis Letal, 50%.
NOEC:	Concentración sin efecto observado.
PNEC:	Predicted No Effect Concentration, (concentración prevista sin efecto) concentración de la sustancia por debajo de la cual no se esperan efectos negativos en el comportamiento medioambiental.
RID:	Regulación concerniente al transporte internacional de mercancías peligrosas por ferrocarril.

Principales referencias bibliográficas y fuentes de datos:
http://eur-lex.europa.eu/homepage.html
http://echa.europa.eu/
Reglamento (UE) 2020/878.
Reglamento (CE) No 1907/2006.
Reglamento (CE) No 1272/2008.

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FICHA DE DATOS DE SEGURIDAD
(de acuerdo con el Reglamento (UE) 2020/878)

2180-HIPOCLORITO SODICO 150G/L - QUIFRANSA

Química del Francolí, S.A.
Subministrament de productes químics

La información facilitada en esta ficha de Datos de Seguridad ha sido redactada de acuerdo con el REGLAMENTO (UE) 2020/878 DE LA COMISIÓN de 18 de junio de 2020 por el que se modifica el anexo II del Reglamento (CE) n.o 1907/2006 del Parlamento Europeo y del Consejo, relativo al registro, la evaluación, la autorización y la restricción de las sustancias y mezclas químicas (REACH).

La información de esta Ficha de Datos de Seguridad del Producto está basada en los conocimientos actuales y en las leyes vigentes de la CE y nacionales, en cuanto que las condiciones de trabajo de los usuarios están fuera de nuestro conocimiento y control. El producto no debe utilizarse para fines distintos a aquellos que se especifican, sin tener primero una instrucción por escrito, de su manejo. Es siempre responsabilidad del usuario tomar las medidas oportunas con el fin de cumplir con las exigencias establecidas en las legislaciones.

-Fin de la ficha de datos de seguridad.-

Xènia Balagué Trepat

Cooling Tower Design

Final Master Project
Adviser: Dr. Francisco González Molina

Master's degree in Industrial Engineering

Document 4: Drawings

UNIVERSITAT ROVIRA I VIRGILI

Tarragona
2023

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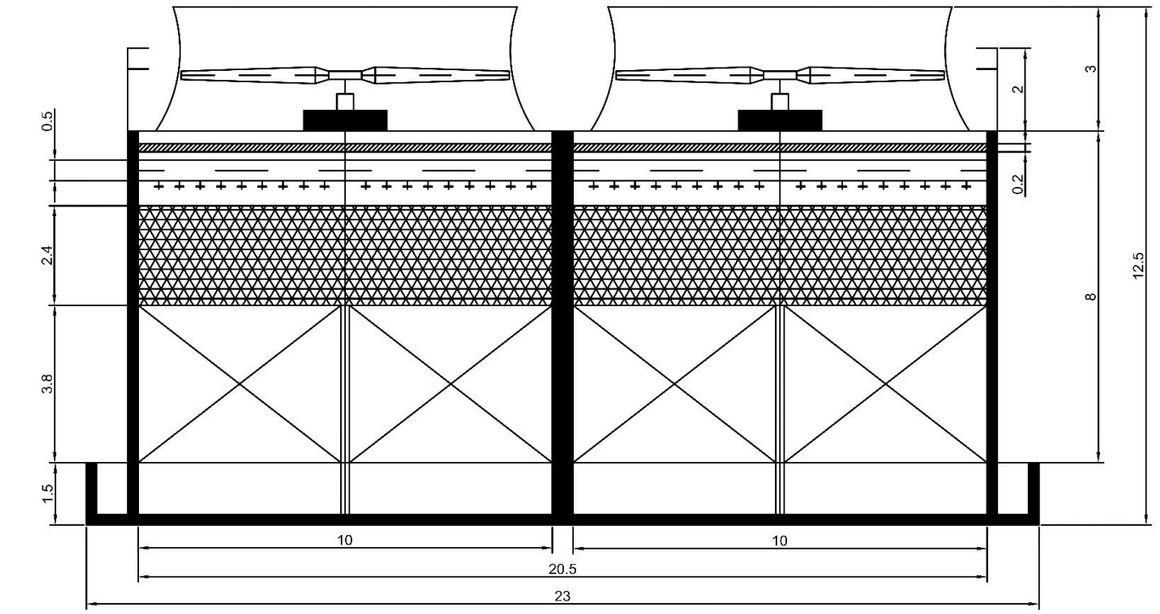
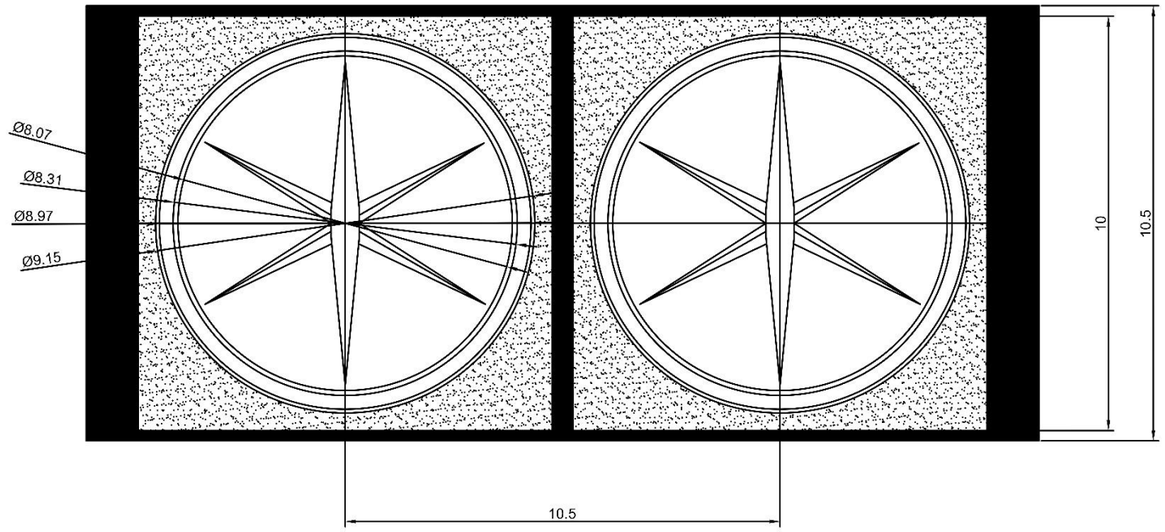
1 Cooling tower dimensions





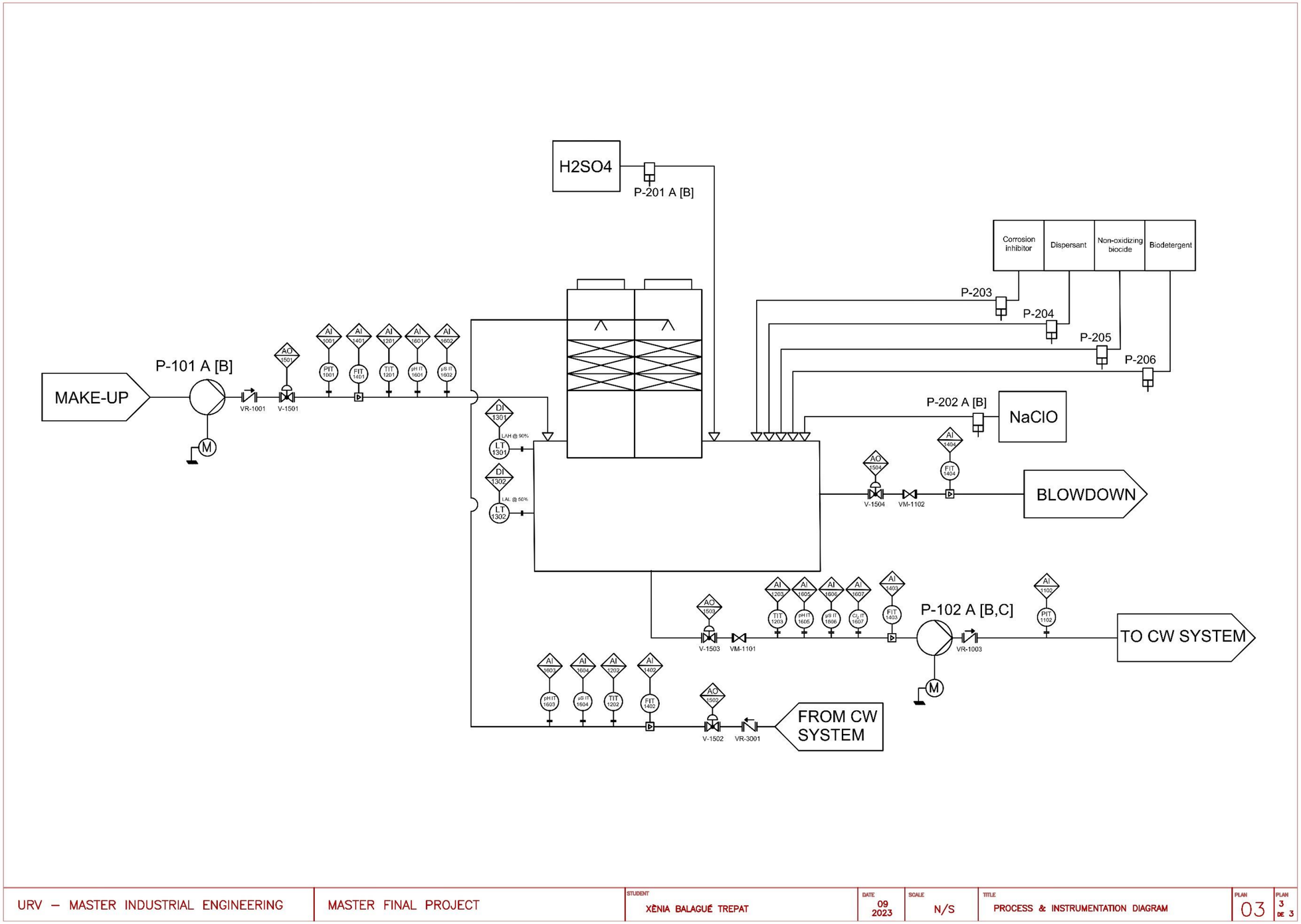
URV – MASTER INDUSTRIAL ENGINEERING	MASTER FINAL PROJECT	STUDENT: XÈNIA BALAGUÉ TREPAT	DATE: 09 2023	SCALE: 1:100	TITLE: COOLING TOWER DIMENSIONS	PLAN: 01	PLAN: 1 DE 3

2 P&ID Symbology

P&ID Symbology					
AO XXX	Analogical output		Dosing pump	PIT XXX	Pressure indicator and transmitter
AI XXX	Analogical input		Centrifugal pump	TIT XXX	Temperature indicator and transmitter
DI XXX	Digital input	M	Motor	FIT XXX	Flow indicator and transmitter
	Check valve	pH IT XXX	pH analyser	LT XXX	Level transmitter
	Manual valve	uS IT XXX	Conductivity analyser	LAH	Level Alarm High
	Automatic valve	Cl_2 IT XXX	Chlorine analyser	LAL	Level Alarm Low

URV – MASTER INDUSTRIAL ENGINEERING	MASTER FINAL PROJECT	STUDENT XÈNIA BALAGUÉ TREPAT	DATE 09 2023	SCALE N/S	TITLE P&ID SYMBOLOGY	PLAN 02	PLAN 2 DE 3

3 P&ID



URV – MASTER INDUSTRIAL ENGINEERING	MASTER FINAL PROJECT	STUDENT: XÈNIA BALAGUÉ TREPAT	DATE: 09 2023	SCALE: N/S	TITLE: PROCESS & INSTRUMENTATION DIAGRAM	PLAN: 03	PLAN: 3 DE 3

Xènia Balagué Trepat

Cooling Tower Design

Final Master Project
Adviser: Dr. Francisco González Molina

Master's degree in Industrial Engineering

Document 5: Budget

UNIVERSITAT ROVIRA I VIRGILI

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1 Budget

1.1 Economic study

The economic study is divided in two parts, the investment costs, and the operating costs.

Investment costs include expenses related to the acquisition of the cooling tower, installation, support systems, and other equipment.

Operating costs include an estimate for the recurring expenses needed to maintain and operate the tower, such as electricity for the fans, cooling water, maintenance, chemicals, among others.

1.2 Investment costs

1.2.1 Personnel costs

A project for a cooling tower design involves a complex process encompassing different professional teams, including:

- Engineers and technicians. Responsible for analysing the project requirements. They perform accurate calculations to size the tower and determine the required cooling capacity.
- Designers. Responsible for converting concepts into precise and detailed technical plans that serve as the basis for construction.
- Project managers. Responsible for coordinating resources and overseeing project progress, ensuring that deadlines are met, and objectives are achieved.
- Construction personnel. Responsible for bringing the design to life by building the cooling tower and carrying out the necessary installations.
- Procurement personnel. Responsible for acquiring the materials and equipment needed for the project.

Considering the different professional teams required for the project, working an 8-hour workday, a total of 1,792 hours per year would be necessary. This calculation is based on a 44-week work year, accounting for holidays and days off.

1.2.2 Cooling tower

The unit cost of the cooling tower encompasses all essential components and materials needed for its design, construction, and efficient operation. Prices have been obtained from different suppliers specialized in this type of supply.

Based the dimensions of the cooling tower, the approximate unit price per cell is around 115,000 €.

1.2.3 Fans

The unit price for the cooling tower fans is approximately 5,000 €. The value has been calculated by the design program.

1.2.4 Water pumps

Table 1.1 includes the unit price for recirculation pumps, make-up water pumps, and the pumps required for each chemical product. Pump prices have been provided by the supplier, in this case, by Flowserve and Grundfos.

1.2.5 Chemical injection system

The chemical injection system includes the supply of Portafeed Senior containers, transfer hoses, level indicators, manifold connections, and tubing to connect the dosing pumps. The average cost of this system typically oscillates at around 3,500 € per unit.

The Portafeed Senior container does not include the product. Therefore, four Portafeed Junior containers have been requested to correspond to each Portafeed Senior.

Additionally, it should be noted that the aforementioned costs correspond to the standard treatment of the system. However, for the initial system startup, additional chemicals that are not part of the regular treatment are required. These additional chemicals will be supplied in barrels and containers of smaller quantities and are shown in Table 1.1.

1.2.6 Civil works

The cost of civil works typically oscillates at around 20% of the total equipment cost. This 20% includes foundation work, site preparation, and construction of the cooling tower.

1.2.7 Instrumentation

Instrumentation percentages range from 2% to 8% of the total equipment quote, depending on the quantity and type of sensors, required automation, and control systems.

This project includes relatively limited instrumentation compared to other equipment i.e., reactors, distillation columns, and represents approximately 2% of the total equipment cost.

1.2.8 Mechanical Assembly

Mechanical assembly encompasses the installation and assembly of the necessary physical and mechanical components of the cooling tower. It generally accounts for 15% of the total equipment cost.

1.2.9 Electrical Assembly

Electricity costs typically range between 3% and 10% of the total equipment budget, depending on the size and complexity of the cooling system and expected energy consumption. For this system, given its small size, it is estimated to represent approximately 5% of the total equipment cost.

1.2.10 Work supervision

Supervision is crucial to ensure the successful implementation of this project. The supervisory team is responsible for monitoring and coordinating all stages of the construction process, from component installation to commissioning. The estimated cost of this supervision is approximately 10% of the total equipment cost.

1.2.11 Total investment costs

The following table provides a complete quote, detailing the previously mentioned categories.

Table 1.1. Detailed Investment Cost.

Personnel cost	Unit	Quantity	Cost (€/h)	Total (€/year)
Engineers and technicians	h/year	1,792	35	62,720
Designers	h/year	1,792	30	53,760
Project managers	h/year	1,792	50	89,600
Construction personnel	h/year	1,792	20	35,840
Procurement personnel	h/year	1,792	25	44,800
			Total personnel cost	**286,720 €**
Material and equipment costs	**Unit**	**Quantity**	**Cost (€/unit)**	**Total (€)**
Cooling tower	units	2	115,000	230,000
Fan	units	2	5,000	10,000
Recirculation pump	units	3	215,000	645,000
Make-up pump	units	2	7,544	15,088
PF senior	units	4	3,500	14,000
Containment trays	units	6	650	3,900
Chemical dosing pumps	units	8	1,645	13,160
			Total material and equipment cost	**931,148 €**
Civil works cost	N/A	N/A	20%	186,230
Instrumentation cost	N/A	N/A	2%	18,623
Mechanical assembly cost	N/A	N/A	15%	139,672
Electrical assembly cost	N/A	N/A	5%	46,557
Work supervision cost	N/A	N/A	10%	93,115
			Total	**484,197 €**
Chemical treatment cost	**Unit**	**Quantity (kg)**	**Cost (€/kg)**	**Total (€)**
NaClO IBC	kg product	1,000	1.50	1,500
H2SO4 IBC	kg product	1,000	2.20	2,200
Corrosion PF Junior	kg product	970	2.00	1,780
Dispersant PF Junior	kg product	890	2.40	1,896
Non-oxidizing biocide PF Junior	kg product	790	4.20	3,318
Biodispersant PF Junior	kg product	790	9.00	7,110
			Total chemical treatment costs	**17,804 €**
Chemical startup products cost	**Unit**	**Quantity (kg)**	**Cost (€/kg)**	**Total (€)**
Dispersant	kg product	150	2.40	360
Corrosion inhibitor	kg product	550	2.00	1,100
Biodetergent	kg product	25	9.00	225
Non-oxidizing biocide	kg product	250	4.20	1,050
			Total chemical startup products cost	**2,735 €**
			TOTAL INVESTMENT COSTS	**1,722,603 €**

Regarding this project, all the costs provided above are approximate. For this reason, it is not possible to provide an exact amount for the total investment cost.

Therefore, the estimated investment cost of this project, including the installation of the cooling tower and chemical treatment, is around 1,800,000 euros.

1.3 Operating costs

1.3.1 Personnel costs

These include the personnel responsible for the operation, monitoring, and maintenance of the cooling tower.

1.3.2 Water costs

Water consumption is an essential part of the cooling process. Currently, the water price stands at 0.5 €/m^3.

1.3.3 Electricity costs

The cost of electrical energy for the cooling tower encompasses a supply for fans, cooling pumps, service water pumps, and chemical injection system pumps. Currently, the electricity cost is 0.168 €/kWh.

1.3.4 Chemical treatment of the tower costs

An estimate of the required quantity of chemical product needed to maintain a proper water quality is included. Quantities and prices have been sourced by various suppliers.

1.3.5 Water quality maintenance costs

Maintaining the tower water quality involves various expenses to ensure the water used in the cooling process meets required standards and remains in optimal conditions. The price shown in the table in the following section represents the annual cost for the following services:

- Analysis equipment: Acquisition and maintenance of laboratory and field analysis equipment to measure physicochemical and microbiological water parameters.
- Disinfections: Conducting and monitoring two annual Legionella disinfections as described in RD.
- External laboratories: Outsourcing of external laboratory services for Legionella analysis.

1.3.6 Total operating costs

The following table reflects the operation costs of the system. For both water service and electricity costs, it has been considered an operating period of approximately 12 hours per day.

Table 1.2. Itemized Operating Costs.

Personnel cost	**Unit**	**Quantity**	**Cost (€/h)**	**Total (€/year)**
Operators	h/year	1,792	40	71,680
Water service cost	**Unit (m3/h)**	**Quantity (h/year)**	**Cost (€/m3)**	**Total (€/year)**
Make-up water	30.85	4,380	0.5	2,190
Electricity cost	**Unit (kW)**	**Quantity (h/year)**	**Cost (€/kWh)**	**Total (€/year)**
Fan	2x55	4,380	0.168	80,942
Recirculation pump	3x240	4,380	0.168	529,805
Make-up pump	2x1.5	4,380	0.168	2,208
Chemical injection pumps	8x0.022	4,380	0.168	12.95
Chemical treatment cost	**Unit**	**Quantity (kg/year)**	**Cost (€/kg)**	**Total (€/year)**
NaClO IBC	kg product	20,100	1.5	30,150
H2SO4 IBC	kg product	20,100	2.2	44,220
Corrosion PF Junior	kg product	1,950	2.0	3,900
Dispersant PF Junior	kg product	4,000	2.4	9,600
Non-oxidizing biocide PF Junior	kg product	1,400	4.2	5,880
Biodispersant PF Junior	kg product	250	9.0	2,250
Water quality maintenance	**Unit**	**Quantity**	**Cost (€/unit)**	**Total (€/year)**
Water measurement and analysis	units	1	1,500	1,500
			TOTAL OPERATING COSTS	**784,331 €**