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RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Design of a water intake network from artesian wells: a case study in a gold mining company.

Design of a water collection network from artesian wells: a case study in a gold mining company.

Design of a water collection network from artesian wells: a case study in a gold mining company.

Rafael Pessotti de Deus

SUMMARY

This work constitutes the result of a case study, which aims to demonstrate the theory for the design of water intake systems from multiple sources, in this case, multiple artesian wells, through a literature review for the conceptualization of the calculations and physics involved in this design.

A specification of the hydraulic pumps used for water extraction in artesian wells is found in the literature review of this case study, and the calculations for flow rate, pressure, and power, as well as a reference model, are found in the conclusions of this work.
This work also presents a conceptualization of the piping used in the project that is the subject of this case study. The main piping in the implemented project is made of a material that has been widely used in industry, depending on the pressure and temperature conditions of the transported fluid. The material used has as its main characteristics low weight, good corrosion resistance, low coefficient of friction between the fluid and the walls, low resistance to low and high temperatures, and low resistance to high pressures.

The specification of the valves and instruments implemented in the project is also an objective of this work. Through the results of this work and with the conceptual information of the valves and instruments described in the literature review of this case study, it is possible to develop the acquisition of the various accessories necessary for the perfect operation of the system, as well as to enable the necessary maintenance, without having to shut down the entire system.

In the conclusions of this work, the results of all the calculations performed are presented. The project was successfully implemented, and the objectives of the undertaking were achieved, within the timeframe and within the budgeted costs.

Keywords: artesian well, hydraulic pumps, industrial piping.

ABSTRACT

This work is the result of a case study, which aims to demonstrate the theory for the design of water collection systems from multiple sources, in this case multiple artesian wells, through a literature review for the conceptualization of calculations and of the physics involved in this dimensioning.

A specification of the hydraulic pumps used to capture artesian wells is found in the literature review of this case study, and the calculations for flow, pressure, and power, as well as a reference model, are found in the conclusions of this work.
This work also presents a conceptualization of the pipes that were used in the project object of this case study. The main pipe of the implemented project is made of a material that has been widely used in industry, depending on the pressure and temperature conditions of the transported fluid. The material used has the main characteristics of low weight, good corrosion resistance, a low friction coefficient between the fluid and the walls, low resistance to low and high temperatures, and low resistance to high pressures.

The specification of valves and instruments implemented in the project is also the objective of this work. Through the results of this work, and in possession of the conceptual information about the valves and instruments described in the literature review of this case study, it is possible to develop the acquisition of the various accessories that are necessary for the perfect

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operation of the system, as well as enabling the maintenance that may be necessary, without the entire system having to be shut down.
In the conclusions of this work, the results of all calculations performed are presented. The project was successfully implemented, and the project's objectives were achieved on time and within the budgeted costs.

Keywords: artesian well. hydraulic pumps. industrial pipes.

1 INTRODUCTION

1.1 Contextualization of the theme

Brazil has always held a prominent position in world gold production. The country was the
the world's largest producer between 1700 and 1850, exploiting surface deposits and
Alluvial deposits made by the Bandeirantes in the Iron Quadrangle region of Minas Gerais. It was in this
The region also housed the first underground mine in Brazil, called the Mine of
Morro Velho, which was operated by the St. John D'El Rey Mining Co., began its operation.
in 1834 (CETEM, 2002).
The author Santos, Márcio José dos (2012) wrote in his master's thesis that gold was
It was officially discovered in the city of Paracatu, Minas Gerais, in the year 1744, by explorers.
Gold mining has been present in this region since its discovery, with bursts of exploitation of
From time to time.
The city of Paracatu is located in the northwest region of Minas Gerais, and the mining company, which is
The subject of this work, the mine, was opened in 1987 in the so-called Morro do Ouro (Gold Hill). The gold ore
Lavrado is a metapelite, and gold occurs in the region in various forms, such as free gold.
disseminated in the rock and concentrated in quartz "boudins," residual gold resulting from
Decomposition of sulfides and carbonates, gold reconcentrated by lateritic processes. The mine
It has an average content of 0.459 g/t, and due to the low average content compared to other veins of
world-class ore and the fact that the northwestern mining region has low rates
Given rainfall patterns, the economically viable exploitation of the ore is a challenge (CETEM, 2001).
The goal of ore processing is to ensure that the discovered and mined mineral resource has
Suitable for use in the metallurgical, chemical, or ceramic industries. This concentration
The processing of the mineral can be done dry, which means that the ore treatment will take place
with the manipulation of particulate solids with natural moisture, or it can be carried out by
Wet, meaning that the ore will have substantial amounts of water added to it.
forming a pulp (CHAVES, AP **Theory and Practice of Mineral Processing).**
The gold beneficiation process in Paracatu begins after the rock is blasted at the mine.
through explosives. The rocks are transported by trucks from the mine to hoppers, which
They feed the two stages of open-circuit crushing. The crushed ore is classified into

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sieves, and the fraction that meets the particle size specifications is transported on conveyor belts to the blending silos and the grinding circuit. At this point, the entire process of The beneficiation process will be wet, and the ore will need to be repulped. The beneficiation process of Morro do Ouro ore, after grinding and classifying the ore pulp into hydrocyclones, then proceed to three flotation cell batteries, two of which are cell batteries. "Cleaners 1 and 2" and a flotation circuit in roughing cells. The ore The concentrate will go to a flotation regrinding circuit to adjust the particle size and then to the concentrate thickeners for adjusting the concentration percentage. of water in the ore pulp. The tailings from the roughing flotation circuit are thickened and transported to the tailings dams. The concentrated ore with the appropriate specification. Particle size and water percentage in the ore pulp will feed into the hydrometallurgy process. (CETEM 2001).

The Paracatu mine has two tailings dams. The first dam built has... capacity to store up to 483 million cubic meters of flotation tailings with safety, and the second dam built has the capacity to store up to 750 million cubic meters of tailings safely handled from flotation (KINROSS company website). In the hydrometallurgical process, an alkaline cyanide solution extracts gold and silver from... ores are extracted through the solvent action of these metals. Almost all gold and silver ores... They can be treated by cyanidation. Cyanide is available in manufactured forms as KCN or NaCN (PEELE, R. **Mining Engineers' Handbook).**

The hydrometallurgical concentrate is pumped to the foundry, from where the final product will be extracted. unit, which consists of bars with an average content of 80% gold and 15% silver (CETEM 2001).

The Paracatu mine has the capacity to process 61 MTPA of ROM and produces up to 17 tons. gold per year. The mine's lifespan is estimated until the year 2030 (company website). KINROSS).

The water consumption at the Morro do Ouro plant corresponds to 2.0 m³/t of treated ROM. (CETEM 2001). The company supplies 85% of this demand with water recovered from the thickeners and from the dams; therefore, for each ton of "run of mine" processed, the company will have to to capture 0.3 m³ of new water (KINROSS company website). With simple calculations, it is possible Estimate a need for new water intake of 18,300,000 m³ per year. Considering To ensure operational availability of the intake systems 80% of the time, the plant must... to capture 2,600 m³/h to maintain gold ore processing operations. The time The water reserved for the maintenance of the intake systems will be supplied by water reservoirs. new at the plant.

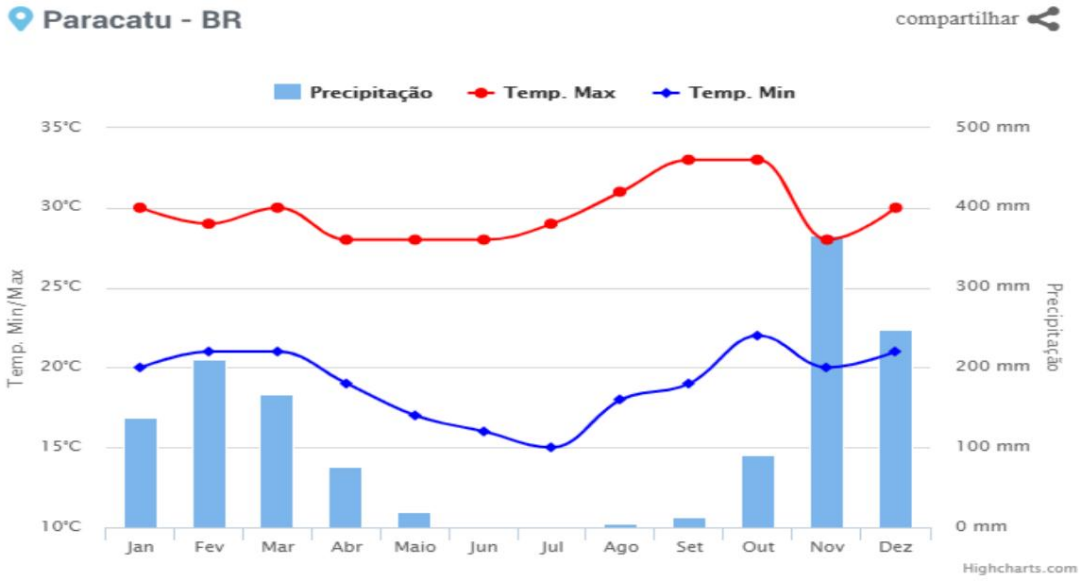
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Measurements over the last 30 years in the city of Paracatu show rainfall...
Annual rainfall is just over 1300 mm, with some months of the year having precipitation.
almost non-existent, as can be seen in the graph below (ClimaTempo). With the need for
Water volume of approximately 18 Mm³ per year for the operation of the plant and production of
Gold and rainfall, as shown in the graph below, represent a creative solution.
This will be necessary to preserve the economic capacity of the mine.

Table 1 – Annual rainfall – Average of the last 30 years



Os dados apresentados representam o comportamento da chuva e da temperatura ao longo do ano. As médias climatológicas são valores calculados a partir de um série de dados de 30 anos observados. É possível identificar as épocas mais chuvosas/secas e quentes/frias de uma região.

Source: Weather

1.2 RESEARCH OBJECTIVES

1.2.1 General objective

The overall objective of this research is to present, through a case study, the project of
sizing of a water intake network originating from artesian wells, for
to supplement the demand for this input for the ore processing plant and
Hydrometallurgy of gold in northwestern Minas Gerais.

1.2.2 Specific objectives

To achieve the overall objective, it is necessary to define the following specific objectives:

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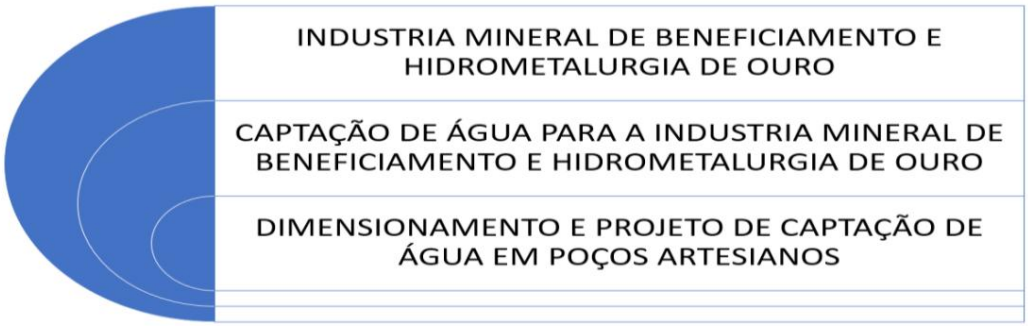
- To identify, through a review of both reference and more recent literature, the main methodologies used in calculating pipe diameter for velocities economically interesting;
- Describe the calculation of head losses in the various intake branches, integrating the Determine the flow rate of the various artesian wells and specify the pumps required for each well;
- Specify the key instruments and valves required for success.

to the project.

1.2.3 Keyword tree

Figure 1 presents the tree of keywords that guided the sorting of the search.

Table 2 - Keyword Tree



Source: Author's own elaboration

1.3 WORK STRUCTURE

This research paper was developed as a case study and has the following structure: chapters as described below:

The INTRODUCTION section aims to provide the reader with a context for the study. case study and the objectives of this work.

The LITERATURE REVIEW chapter presents a review of the traditional literature with an established bibliography and a review of cutting-edge literature with a more comprehensive bibliography. recent. The work demonstrates the main mathematical tools for calculation and Specification of equipment, valves and pipes to meet the need set by Gold processing plant in Paracatu.

The third part of the research, called METHODOLOGY, outlines the steps for development. This section describes the methods used to develop this case study.

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The ANALYSIS AND INTERPRETATION OF RESULTS details the main steps of
Calculation and specification of piping systems used for water intake through
of artesian wells according to the basic premises and criteria of the project.
The final chapter of this case study presents the CONCLUSIONS and the results obtained with the...
Project implementation. This part of the work also covers the main operational conditions.
so that the system is successful enough in meeting the demands.

2. LITERATURE REVIEW

2.1 Definition and general information about projects

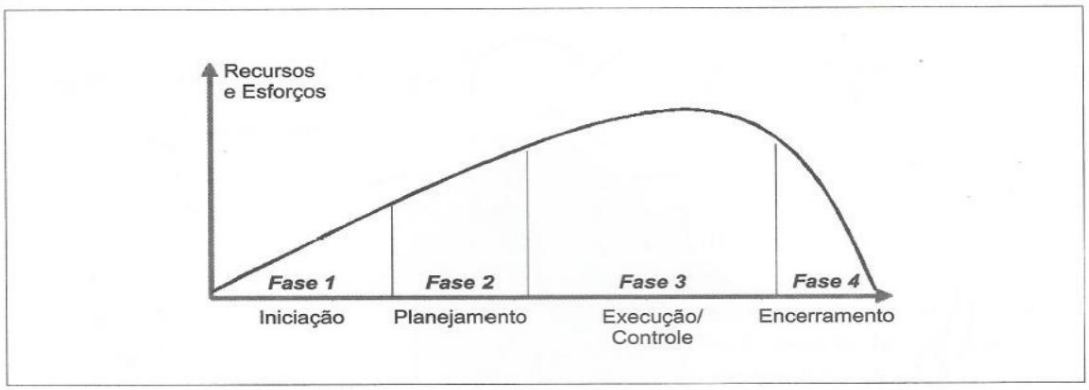
The definition of a project, according to Dinsmore, Paul Campbell et al. in Project Management
– How to Manage Your Project with Quality, on Time and within Budget (2012), is
an effort with a beginning and an end that is made with the goal of creating a product or service that
be different, at least in some way, from all other products and services.
available. According to the author, a project uses resources and is managed by people who should...
to comply with cost, time and quality parameters.
According to Sun Tzu et al. in The Art of War and Management (2005), planning
Deficiency causes loss of capital and also of jobs, due to a lack of preparation for
the different stages of the project.
The life cycle of a project will consist of four phases. The first phase will be executed.
so that a conception of the concept is possible and to establish its feasibility by comparing it.
the alternatives. The second phase will involve the development of the project plan, of
The planning of human, material, and financial resources will be marked by the development of
The project plan, which aims to obtain approval for project execution. The third phase, if
Once approved, the next phase will be the execution and control of the programmed activities, with the adaptation of...
plan where necessary. The fourth phase of the project will be the closing phase, marked by
commissioning of the facilities, training of operational personnel, and relocation of
project team for other activities (DINSMORE, PC Project Management - How
Manage your project with quality, on time and within **budget.**

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Table 3 – Distribution of activity level throughout the life cycle of a project



Source: Project Management – How to Manage Your Project with Quality, within the
Estimated Timeline and Costs

The development of a water supply system begins with the preparation of studies and
Projects for defining the works to be undertaken. The service period for the works.
The projected costs vary according to the need and planning for the use of this water. Some
The initial project guidelines are defining the objective, defining the level of detail, and...
precision of the system components, the economic and financial aspects and conditions, and the
Definitions of local conditions and parameters. Some basic elements for the project are the
topographical configurations and geological and geotechnical characteristics of the region, consumers a
to be served and its distribution in the area to be supplied, quantity of water required, integration
with any existing system, research and definition of water sources or other sources of water,
compatibility between the parts of the proposed system, system operation method, steps of
Implementation, technical and economic comparison between concept options, and feasibility.
Financial aspects of the basic design (AZEVEDO NETTO, JM **Manual of Hydraulics).**
Several factors are involved in developing a piping engineering project for industry.
Considerations that must be observed. The work should be prepared taking into account the
system service conditions to understand the various requirements that will need to be met.
obeyed. The pipeline layout must provide sufficient flexibility to absorb
Stresses resulting from thermal expansion in the lines. The stresses and vibrations of the pipes do not
They must be transmitted to the equipment nozzles if these charges are above the
Maximum loads that the equipment can support. The design should provide for ease of assembly.
and painting of the pipes, as well as the maintenance that will be carried out in the future. Safety
During assembly, operation, and maintenance, the individual must direct the work throughout the design phase.
The most efficient pipeline layout will always be the one with the best economic conditions.
Obviously respecting the other basic conditions. These influencing factors are conflicting.

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among themselves on various occasions, and for each circumstance there will be a more suitable solution. (SILVA TELLES, PC **Industrial Piping – Materials, Design, Assembly).**

2.2 Concepts of Fluid Mechanics

From a certain point of view, matter can be found in nature in only two states,
Fluids or solids. The difference between these two states is linked to the reaction of each to...
application of a shear stress. While a solid can withstand a stress of
Shear due to static deformation, a fluid cannot. Any stress of
Shear applied to a fluid, no matter how small, will result in movement.
of this fluid. Fluid Mechanics is the study of fluids at rest or in motion and
of the effects of these on the boundaries, which can be solid surfaces or interfaces with
other fluids. Gases and liquids are classified as fluids, and their applications in
Engineering is enormous (WHITE, FM **Fluid Mechanics).**
Another way to approach the difference between solids and fluids is the different way in which each state...
It shows its intermolecular bonds. The molecules in solids are closer together.
unlike others, whereas in gases these same molecules are separated by distances
relatively larger, and the macroscopic result is that the solids have bonds
Intermolecular forces are stronger than those of gases. Liquids have molecular bonds that are stronger than those of gases.
with the magnitude of the force between the bonds of solids and gases (ÇENGEL, YA **Mechanics Fluids – Fundamentals and Applications).**
In the study of fluid mechanics, there are four dimensions from which all others are derived.
These dimensions, which are called primary dimensions, are mass, length, time, and
Temperature. Secondary properties, which by definition derive from the properties
primary solutions can be the solution or the path to solving various problems.
Fluid mechanics. The properties of the velocity field, for example, are in the first place.
Its place among the properties of a flow, given that other properties follow.
directly from the determination of the velocity field of a flow, such as, for example,
the pressure field or the temperature field (WHITE, FM **Fluid Mechanics).**
Viscosity is another important property of fluids considered secondary, since...
It also derives from primary properties. When two layers of a fluid move, one
In relation to each other, a frictional force will develop between them, causing resistance.
internal resistance to the movement of this fluid. This internal resistance to movement is the fluid itself.
Fluid viscosity. Viscosity is caused by cohesive forces between molecules in a liquid.
and by molecular collisions in gases. There is no fluid with zero viscosity and, therefore, every

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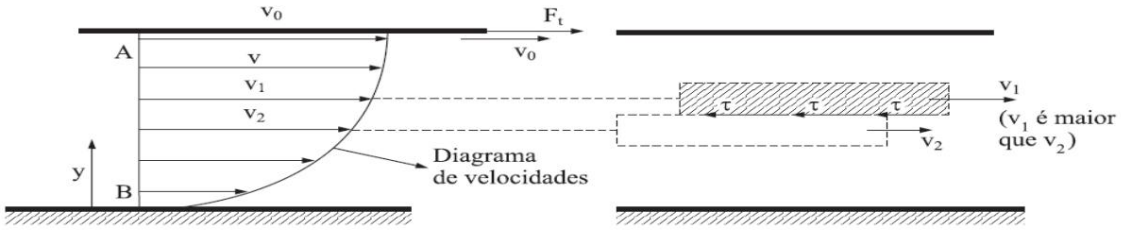
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Fluid flow involves viscous effects to some degree (ÇENGEL, YA **Mechanics of Fluids – Fundamentals and applications.**

Isaac Newton realized that, in many fluids, the shear stress in the fluid was proportional to the velocity gradient in the fluid layer. This constant of The proportionality was termed the dynamic viscosity coefficient μ. The fluids that Fluids that meet this linear proportionality are considered common and are called fluids. Newtonian fluids. Examples of Newtonian fluids are water, oils, and air. The figures and the The equation below presents the mathematical and physical formulation of the viscosity coefficient. Dynamics for Newtonian fluids (BRUNETTI, F. **Fluid Mechanics):**

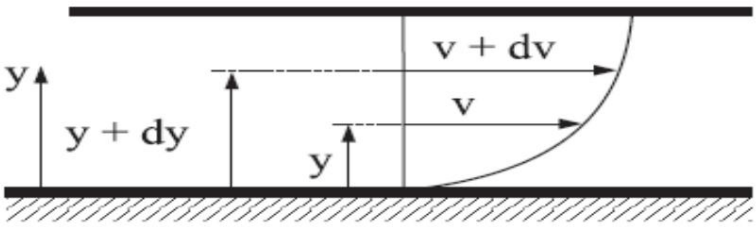
$$\tau \alpha \frac{dv}{dy} \qquad ou \qquad \frac{\tau}{\frac{dv}{dy}} = c^{te} \qquad \tau = \mu \frac{dv}{dy}$$

Figure 1 – Fluid element deforming as a shear stress is applied.



Source: Fluid Mechanics

Figure 2 – Velocity distribution in a sheared layer near a wall



Source: Fluid Mechanics

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Table 1 – Dynamic viscosity of eight fluids at 1 atm and 20°C

Fluid	μ, kg/(m · s)
Hydrogen	8.8 E–6
Air	1.8 E–5
Gasoline	2.9 E–4
Water	1.0 E–3
Ethyl alcohol	1.2 E–3
Mercury	1.5 E–3
SAE 30 oil	0.29
Glycerin	1.5

Source: Fluid Mechanics

The viscosity of Newtonian fluids is a thermodynamic property that varies with the
The pressure and temperature to which the fluid is subjected. In general, the viscosity of gases and
The temperature of liquids increases slightly with increasing pressure. However, temperature provides...
a more noticeable effect in fluids. In gases, an increase in temperature also increases μ,
while in liquids, an increase in temperature causes μ to decrease (WHITE, FM)
Fluid Mechanics.

Table 2 – Variation of freshwater viscosity with temperature

Temperatura °C	μ (N × s/m²) × 10^{-6}	Temperatura °C	μ (N × s/m²) × 10^{-6}
0	1.791	40	653
2	1.674	50	549
4	1.566	60	469
5	1.517	70	407
10	1.308	80	357
15	1.144	90	317
20	1.008	100	284
30	799		

Source: Hydraulics Manual

To understand the velocity field distribution in a pressurized conduit, it is necessary
To understand the concept of a boundary layer and how it develops in a pressurized conduit.
Initially, we will propose an understanding of the boundary layer, considering a flow.
on a flat plate. The friction of the plate with the first layer of fluid will be relatively
large, and it can be considered that the fluid will be stationary in this layer. The second layer
It will experience internal friction due to the viscosity of the fluid itself and will have a velocity.
relatively small. The third layer of fluid will experience less friction due to the

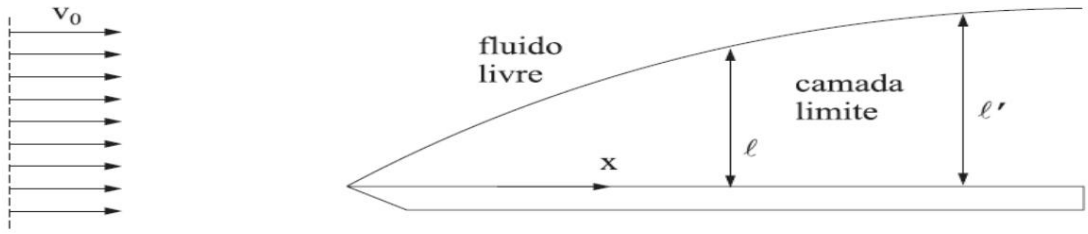
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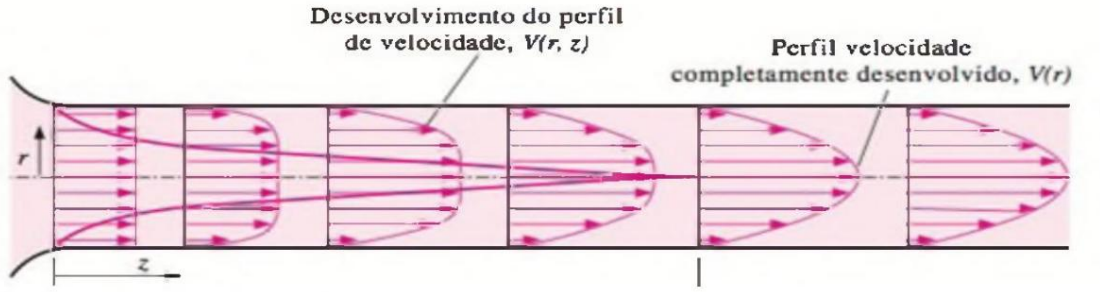
viscosity of the medium, due to the small movement of the second layer, and so on, until
that a layer is reached that will not suffer from internal friction. This will be the boundary layer, and
Its development is represented below for a flow over a flat plate and
inside a forced conduit (BRUNETTI, F. **Fluid Mechanics):**

Figure 3 – Development of the velocity profile in a flow over a flat plate.



Source: Fluid Mechanics

Figure 4 – Development of the velocity profile in a circular tube



Source: Fluid Mechanics – Fundamentals and Applications

Some flows have their layers sliding over each other in a relatively...
ordered, while other flows are characterized by their chaotic nature in which the
The layers move over one another. The ordered movement of fluid layers is
called laminar flow. Fluids with relatively high viscosities and velocities of
Relatively small transport patterns are typically laminar. Flow with layers
Disordered flow is called turbulent flow and generally occurs in transport with high speeds.
relatively high viscosities and relatively low viscosities. A flow that alternates between
Laminar and turbulent flow is called transitional. The flow regime has a great influence.
on the power required for pumping (ÇENGEL, YA **Fluid Mechanics –**

Fundamentals and applications

Generally, due to its significant influence on the power required for pumping, the
The first thing a fluids engineer must do is infer the type of flow.
which will be worked on. The dimensionless Reynolds number, a product of the experiments performed

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Introduced by Osborne Reynolds in 1880, this number is used to determine the type of flow.
A low Reynolds number implies laminar flow, and a high Reynolds number means...
A turbulent flow. Explicit numerical values for low Reynolds numbers.
or high values vary according to the geometry of the conduit (WHITE, FM **Fluid Mechanics).**
The volume of fluid that passes through a given cross-section is called the flow rate.
a given unit of time. Flow rate is expressed in various units. For calculation of
In piping, some authors use the unit liters per second (l/s). Some drills
Wells and some pump suppliers commonly use liters per hour (l/h). Other units
Other units used are cubic meters per hour (m^3/h) or even in English units, cubic feet per
minute (CFM). An important definition for this moment is the movement or regime.
Steady state is the flow regime in which the characteristics of the flow are a function of the steady state.
The location of a point in space is not a function of time. With this definition, it is possible to...
Using the general equations of motion, define the continuity equation, represented as...
below (AZEVEDO NETTO, JM **Manual of Hydraulics).**

Table 3 – Continuity equation

Q=ÿ*V*A	For gases whose ÿ varies as a function of location of the point in space
Q=V*A	For liquids considered relatively incompressible

Source: Fluid Mechanics

The natural roughness or unevenness of the inner walls of the pipes will also be relevant.
when it is necessary to calculate the energy lost by the system during fluid flow.
Each conduit, with its respective material and construction method, will exhibit its own roughness.
natural. The average height of this roughness is expressed by ÿ. For the study of head loss in
In fluid flow, we can easily understand that average roughness alone does not...
will be sufficient, due to the concept of the flow development boundary layer, and yes to
relationship between conduit diameter and average roughness DH/ÿ (BRUNETTI, F. **Mechanics of Fluids).**
In addition to the resistance to internal movement within the fluid itself, the implications of the type of
Besides the flow present in the system and the friction with the piping, there is yet another form of loss.
energy loss in the transported flow. Any accessory or accident in the conduit causes losses of
load of a different nature than friction with straight pipes and viscous and turbulent effects.
These pressure losses are caused by changes in direction, accelerations, and intensification of...

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Machine Translated by Google
RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Friction, turbulence, and dynamic shocks. The evaluation of this type of pressure loss usually...
to be exclusively empirical. Each accessory, such as valves and bends, with its respective
The diameter is tested experimentally, and the same straight pipe length is determined.
It is equivalent to that accessory. There are more precise formulas than this method, but coefficients
These formulas must be obtained in the same experimental way (SILVA TELLES, PC

Industrial Piping – Calculation.

In a pipeline project, the main issue will be determining the amount of energy.
necessary for the fluid to flow in the desired quantity between two or more points of
interest. Chézy, in France, presented the first formula that attempted to express algebraically
resistance to flow in a conduit, and after that, several expressions were proposed for it.
same fate. Darcy had the merit of being the first to consider the nature and state of the walls.
of the pipes and presented a formula whose application has been recognized and assured for about
150 years. Due to the need to establish a coefficient for the use of the formula of
Darcy, a simpler formula was proposed and became established through use, known as the formula.
Hazen-Williams. Numerous expressions have been proposed for calculating head loss.
in a conduit, and some authors report that there are more than one hundred expressions, and the use
The drawback of these formulas, without a proper understanding of their limitations, can lead to...
Errors greater than what is tolerable (AZEVEDO NETTO, JM **Manual of Hydraulics).**
Another major contribution to the definition and dimensioning of pressure loss in a system.
for drainage in ducts, both circular and non-circular, and is also adapted for a
For approximating boundary layer flows, the Moody diagram is useful (WHITE, FM).

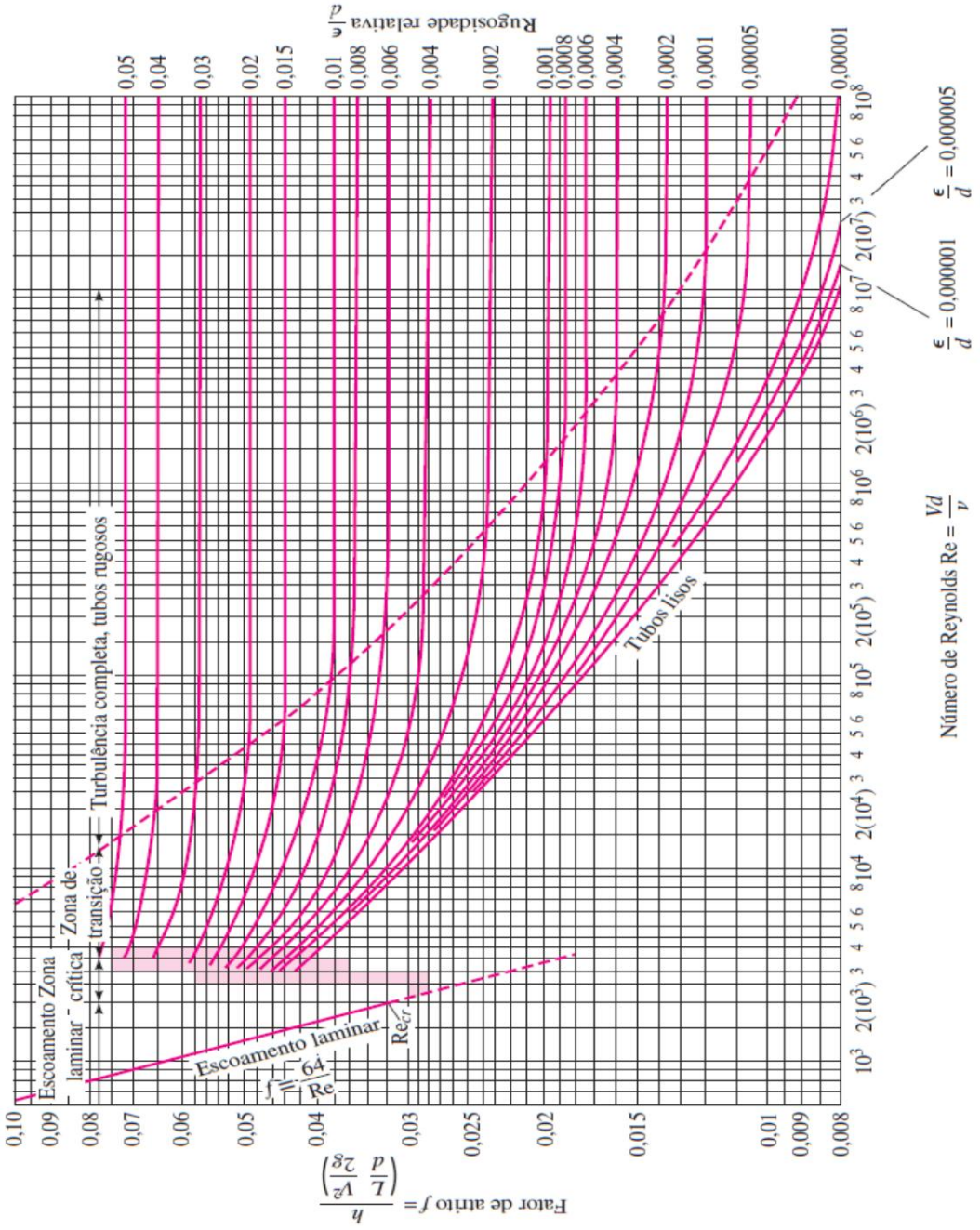
Fluid Mechanics.

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Table 4 – Moody Diagram



Source: Fluid Mechanics

There is yet another important characteristic that the hydraulic engineer should pay attention to: the vapor pressure. If the pressure to which a liquid is subjected is below the vapor pressure,
Bubbles begin to form in the liquid. When the liquid pressure drops below the vapor pressure.
Due to some flow phenomenon, a process called cavitation will occur.
The sizing of the piping system should take cavitation into account and
Ideally, this process should not be allowed to occur, due to the fact that cavitation is...

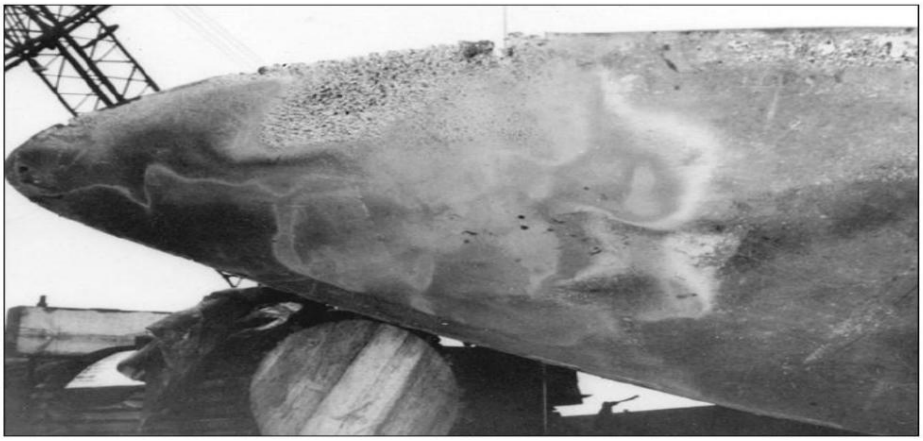
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responsible for mechanical damage to the equipment involved (WHITE, FM **Mechanical of Fluids).**

Figure 5 – Erosion caused by the collapse of cavitation bubbles in a marine propeller.



Source: Fluid Mechanics

2.3 Characterization of pumps

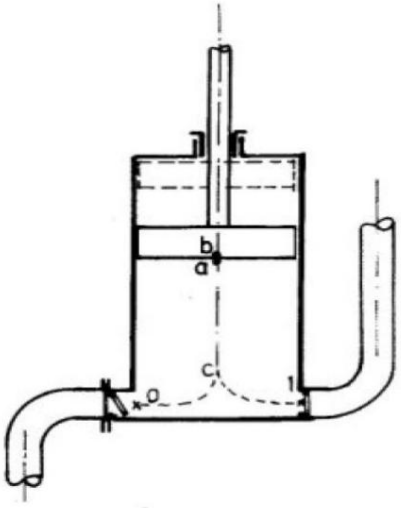
Hydraulic pumps are machines that generate mechanical work and transform it.
in hydraulic energy, imparting an increase in energy to the liquid in the forms of kinetic energy and Pressure vessels. These are devices whose purpose is to move a liquid.
(MACINTYRE, AJ **Pumps and Pumping Installations).**
There are two basic types of pumps. Positive displacement or volumetric pumps, which
They force the displacement of the fluid by changing the volume of a specific chamber in
Equipment designed for this purpose. There are several different types of displacement pumps.
Yes, but in its simplest form, a cavity opens during suction when a plunger...
The chamber's volume increases, and soon after, another cavity opens, while the same piston...
It reduces the volume of the chamber, performing the pumping action. Dynamic pumps, in turn,
They simply add momentum to the fluid. The fluid with velocity passes
through a section of the equipment in the form of a diffuser, and the kinetic energy is converted into pressure energy (WHITE, FM **Fluid Mechanics).**

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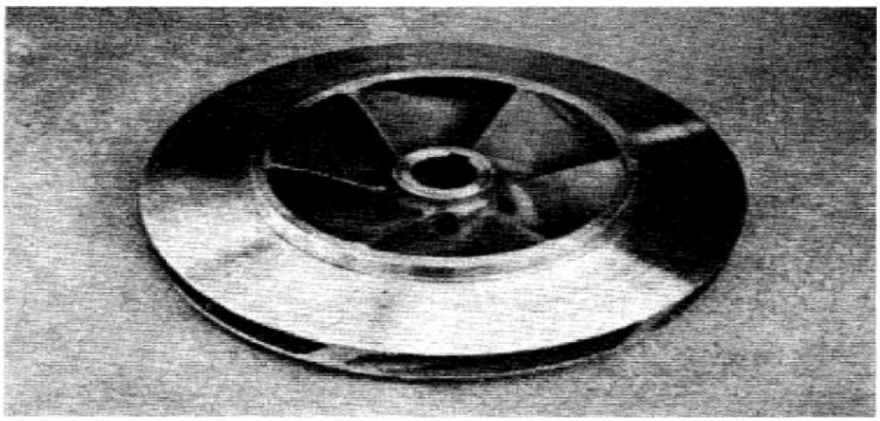
Figure 6 – Diagram of a piston-type positive displacement pump



Source: Pumps and pumping installations

Dynamic pumps, also called rotodynamic pumps, kinematic pumps or
Turbopumps are characterized by having a rotating element equipped with blades, which exerts... a force acts on the liquid, imparting an acceleration to it. The resulting discharge depends on the characteristics of the pump, the number of rotations and the characteristics of the suction piping and pumping (MACINTYRE, AJ **Pumps and Pumping Installations).**

Figure 7 – Diagram of a piston-type positive displacement pump



Source: Pumps and pumping installations

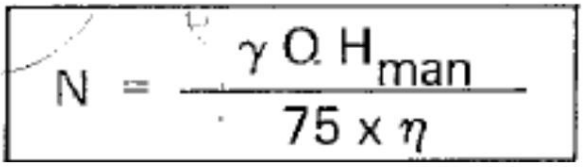
Professor Djalma Francisco Carvalho (1999) wrote in his book “Elevating Installations.
"Pumps" is the equation for calculating the power required for the pump motor. The formula
The calculation in horsepower (hp) is described below:

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Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Table 5 – Equation for calculating the power of hydraulic pumps



Source: Lifting installations. Pumps

Total income, according to Professor Djalma Francisco Carvalho (1999), is the product of three factors: hydraulic efficiency, which takes into account surface finish.

The volumetric efficiency, which takes into account the internal walls of the rotor and the pump casing, is a key factor in the overall efficiency of the pump.

It accounts for recirculation in the pump volute and leakage from the equipment's packing gland, and Mechanical efficiency, which corresponds to the power required to overcome resistance.

passive pump properties.

In water pumping systems, the range of flow rates and manometric heights can be wide, and One possible solution is to connect two or more pumps in series or parallel.

A series of pumps is mainly used when there are different pressure conditions.

In the process, while the parallel connection of equipment is more commonly used for processes that require different flow rate conditions. Parallel association results in a flow rate lower than the sum of the flow rates of the pumps used individually, because the system with pumps in parallel it operates with higher manometric head values than the values with the same system with only one of the pumps operating (MACINTYRE, AJ **Pumps and Pumping installations.**

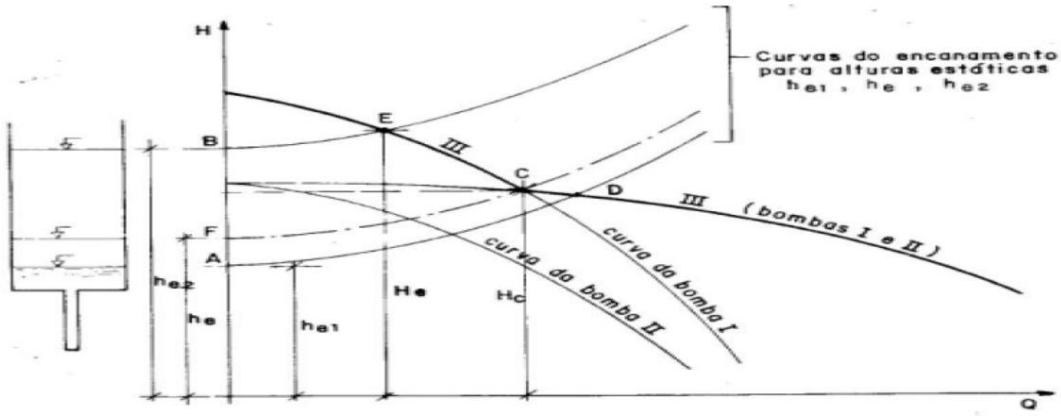
Using different pumps connected in parallel is feasible, but requires a thorough evaluation. from the curve of the pumps individually and also from the curve resulting from the association due to many problems that can arise (CARVALHO, DF **Elevating installations. Pumps).**

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Table 4 – No effect on flow gain with parallel pump connection on curves
different characteristics



The water that seeps into the soil and passes through the humus layer, the transition zone, and the fringe of
Capillary action reaches the so-called saturation zone and will constitute the unconfined aquifer or water table.
Groundwater. This water, which saturates the permeable granulometric material of the aquifer, can be
Water is withdrawn and utilized through the installation of associated wells, ranging from rudimentary systems to...
Modern pumps. Very deep wells generally use multi-stage pumps, with
Special thrust bearings to support the self-weight of the shaft and rotors and the axial thrust.
(MACINTYRE, AJ **Pumps and Pumping Installations).**

Figure 8 – Multistage well pumps



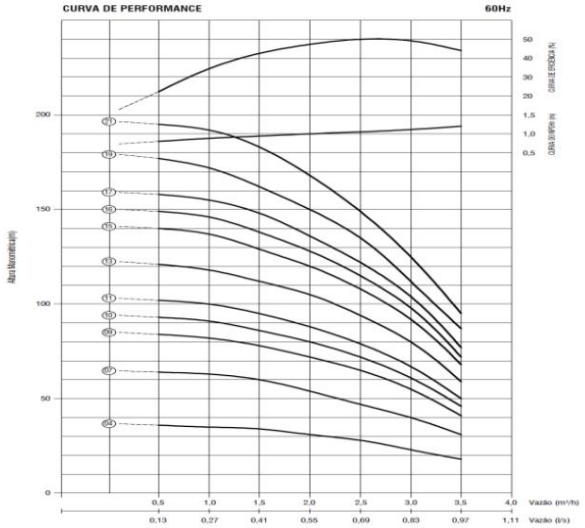
Source: EBARA

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Figure 9 – Typical characteristic curve of a well pump



Source: EBARA

2.4 Piping materials used in the Industry

The importance of piping in all industrial sectors is enormous. Piping is used...
for transporting all materials that have the capacity to flow, that is, all the
known fluids, pasty materials, and fluids with suspended solids. An increasingly larger range
A wider range of pressures and temperatures is met for all types of flowable materials.
made from a wide variety of materials. The manufacturing processes are also diverse.
of these tubes, each material and each process with its advantages and disadvantages (SILVA
TELLES, PC **Industrial Piping – Materials, Design, Assembly).**
An important point in choosing the pipe material for a given application is its capacity.
to maintain physical characteristics for a reasonable period of time. There is no surface
perfectly smooth and, moreover, all piping used in the industry is subject to
The phenomenon of aging. Pipes in general become rougher over time due to this.
various reasons. Pipelines constructed with ferrous material without permanent coating.
They suffer from increased roughness in a particular way, due to the effect of corrosion and
incrustation (AZEVEDO NETTO, JM **Manual of Hydraulics).**
Plastic pipes are currently considered by some authors to belong to the group
One of the most important non-metallic materials for industries. HDPE, for example, is a
HDPE is a lightweight thermoplastic material with good resistance to mineral acids, alkalis, and salts.
It can be used for conveying various fluids at moderate pressures and temperatures.
HDPE, like other plastic materials, has low natural roughness and resists well to

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corrosion and fouling (SILVA TELLES, PC **Industrial Piping – Materials, Design, Assembly).**

Table 6 – Dimensions and allowable pressures for HDPE pipes

	SDR 33		SDR 26		SDR 21		SDR 17,6		SDR 17		SDR13,6		SDR 11		SDR 11		SDR 9		SDR 7,4		SDR 6	
PE 80	PN 4		PN 5		PN 6		PN 2,4		PN 8		PN 10		PN 4		PN 12,5		PN 16		PN 20		PN 25	
PE 100	PN 5		PN 6		PN 8		PN 4		PN 10		PN 12,5		PN 7		PN 16		PN 20		PN 25			
DE mm	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m	e mm	Peso médio kg/m
20							2,3	0,137					3,0	0,167	2,0	0,117	2,3	0,137	3,0	0,158	3,4	0,187
25							2,3	0,175			2,0	0,153	3,0	0,175	2,3	0,178	3,0	0,205	3,5	0,248	4,2	0,288
32							2,3	0,229	2,0	0,200	2,4	0,238	3,0	0,287	3,0	0,287	3,6	0,337	4,4	0,406	5,4	0,470
40					2,0	0,253	2,3	0,292	2,4	0,302	3,0	0,366	3,7	0,443	3,7	0,443	4,5	0,525	5,5	0,630	6,7	0,728
50	1,8	0,299	2,0	0,369	2,4	0,383	2,9	0,452	3,0	0,466	3,7	0,566	4,6	0,688	4,6	0,688	5,6	0,815	6,9	0,969	8,3	1,128
63	2,0	0,416	2,5	0,506	3,0	0,595	3,6	0,709	3,8	0,743	4,7	0,902	5,8	1,087	5,8	1,087	7,1	1,280	8,6	1,539	10,5	1,792
75	2,3	0,574	2,9	0,693	3,6	0,852	4,3	1,008	4,5	1,048	5,6	1,277	6,9	1,537	6,8	1,537	8,4	1,830	10,3	2,189	12,5	2,538
90	2,8	0,824	3,5	1,006	4,3	1,221	5,1	1,433	5,4	1,507	6,7	1,831	8,2	2,200	8,2	2,200	10,1	2,607	12,3	3,153	15,0	3,656
110	3,4	1,219	4,2	1,508	5,3	1,834	6,3	2,153	6,6	2,242	8,1	2,740	10,0	3,263	10,0	3,263	12,3	3,921	15,1	4,689	18,3	5,445
125	3,9	1,573	4,8	1,937	6,0	2,343	7,1	2,571	7,4	2,894	9,2	3,527	11,4	4,233	11,4	4,233	14,0	5,028	17,1	6,058	20,8	7,024
140	4,3	1,959	5,4	2,401	6,7	2,934	8,0	3,457	8,3	3,591	10,3	4,413	12,8	5,311	12,7	5,311	15,7	6,321	19,2	7,603	23,3	8,817
160	4,9	2,522	6,2	3,149	7,7	3,849	9,1	4,512	9,5	4,687	11,8	5,755	14,6	6,925	14,6	6,925	17,9	8,236	21,9	9,905	26,6	11,497
180	5,5	3,199	6,9	3,972	8,6	4,836	10,2	5,683	10,7	5,928	13,3	7,298	16,4	8,754	16,4	8,754	20,1	10,405	24,6	12,531	29,9	14,532
200	6,2	4,001	7,7	4,863	9,6	5,993	11,4	7,043	11,9	7,316	14,7	8,999	18,2	10,795	18,2	10,795	22,4	12,899	27,4	15,443	33,2	17,941
225	6,9	4,970	8,6	6,174	10,8	7,572	12,8	8,880	13,4	9,278	16,6	11,352	20,5	13,663	20,5	13,663	25,2	16,251	30,8	19,580	37,4	22,725
250	7,7	6,169	9,6	7,642	11,9	9,268	14,2	10,962	14,8	11,440	18,4	14,044	22,7	16,868	22,7	16,868	27,9	20,080	34,2	24,124	41,5	28,015
280	8,6	7,711	10,7	9,523	13,4	11,699	15,9	13,713	16,6	14,286	20,6	17,579	25,4	21,138	25,4	21,138	31,3	25,249	38,3	30,289	46,5	35,150
315	9,7	9,806	12,1	12,120	15,0	14,702	17,9	17,361	18,7	18,091	23,2	22,258	28,6	26,748	28,6	26,748	35,2	31,838	43,1	38,308	52,3	44,478
355	10,9	12,543	13,6	15,304	16,9	18,666	20,1	22,007	21,1	23,024	26,1	28,194	32,3	33,941	32,2	33,941	39,7	40,503	48,5	48,608	59,0	56,509
400	12,3	15,762	15,3	19,393	19,1	23,802	22,7	27,995	23,7	29,209	29,4	35,836	36,4	43,081	36,3	43,081	44,7	51,405	54,7	61,731		
450	13,8	20,310	17,2	25,058	21,5	30,622	25,5	35,075	26,7	37,506	33,1	46,131	41,0	55,481	40,9	55,481	50,3	66,075	61,5	79,017		
500	15,3	25,017	19,1	30,879	23,9	37,781	28,3	44,328	29,7	46,341	36,8	56,945	45,5	68,445	45,4	68,445	55,8	81,648				
560	17,2	31,444	21,4	38,667	26,7	47,284	31,7	55,564	33,2	58,053	41,2	71,303	51,0	85,870	50,8	85,870						
630	19,3	39,807	24,1	48,949	30,0	59,732	35,7	70,379	37,4	73,528	46,3	90,233	57,3	108,598	57,2	108,598						
710	21,8	50,618	27,2	62,168	33,9	76,054			42,1	93,296	52,2	114,537			64,5	137,994						
800	24,5	64,137	30,6	78,680	38,1	96,401			47,4	118,524	58,8	145,501			72,6	175,001						
900	27,6	81,107	34,4	99,709	42,9	121,975			53,3	149,898	66,2	183,161			81,7	221,515						
1000	30,6	100,215	38,2	122,936	47,7	150,697			59,3	184,951	72,5	223,083			90,2	271,963						
1200	36,7	144,131	45,9	177,027	57,2	216,901			67,9	257,929	88,2	325,297										
1400	42,9	196,006	53,5	240,751	66,7	298,672			82,4	364,248	102,9	447,083										
1600	49,0	255,838	61,2	314,484	76,2	389,823			94,1	475,195	117,6	583,708										
1800	54,5	316,872	69,1	398,428	85,7	487,994			105,9	595,021												
2000	60,6	391,135	76,9	491,794	95,2	602,417			117,6	734,610												
2100	63,6	431,193	80,8	542,124	100,0	664,148																
2300	69,7	517,164	88,5	650,180	109,5	796,649																
2500	75,8	610,943	96,2	768,198	119,0	941,065																

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Source: FGS Brazil

The disadvantages of HDPE pipes and plastic pipes in general are their low resistance to...
heat, low mechanical strength, poor dimensional stability, high coefficient of
expansion and the fact that the material is combustible must be taken into account to ensure the
system safety (SILVA TELLES, PC **Industrial Piping – Materials, Design, Assembly).**

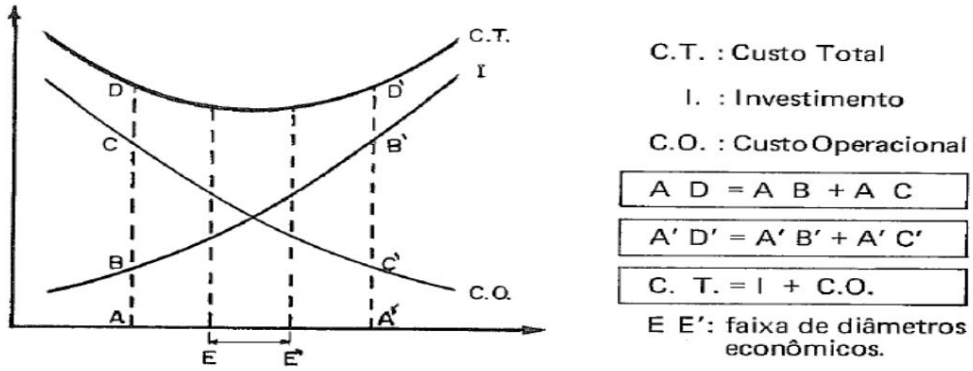
The economic aspect will always be an important characteristic to consider for the project.
of the lifting system. Considering the continuity equation Q=V*A, it is
It is easy to see that the same pipe diameter can carry different
flow rates can be increased simply by changing the transport speed. However, varying the diameter has...
Direct relationship with initial investment and operating cost. The larger the diameter of the
The higher the installation, the greater the initial investment, but the lower the operating cost, because the
The motor power will be lower. After verification in several pumping installations,
It was found that meeting the criterion of combining initial investment and operating cost
This meant maintaining an average suction speed of approximately 1.5 m/s.
average velocity in the discharge pipe of approximately 2.5 m/s (CARVALHO, DF **Installations)**
Elevating stations. Pumps).

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Machine Translated by Google
RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Table 5 – Variations in investment, operating cost and total cost with diameter



Source: Lifting installations. Pumps

2.5 Shut-off and control valves used in industry

Valves are devices designed to control the flow of fluids in systems through which
These fluids flow. Some valves are used to stop the flow to allow...
Disassembly and repair of the installation; others ensure the safety of the installation, and there are
others regulate the flow, allowing for greater or lesser volume. There is a large
There is a wide variety of valve types, and each type can be further subdivided into a variety of subtypes.
Choosing the best option depends on the nature of the operation, the physical properties, and
fluid chemistry, and system pressure and temperature (MACINTYRE, AJ **Pumps and Pumping installations.**

Valves are commonly divided into (SILVA TELLES, PC **Industrial Piping – Materials, Design, Assembly):**

1. Shut-off valves: These are designed to establish or interrupt flow. They operate
Completely open or completely closed. Examples include gate valves,
male, ball and gate or guillotine type;
2. Regulating valves: They operate in any partially closed position and are used
to control the flow. Examples include globe valves, needle valves, butterfly valves, and...
diaphragm;
3. Check valves: which allow flow in only one direction. Examples include...
foot valve and check valve.
4. Upstream pressure control valves: Valves used to ensure the pressure of
Fluid upstream in the piping. Examples include safety and relief valves and the valve...
excess flow rate;
5. Downstream pressure control valve: A valve that ensures the fluid pressure at
downstream in the piping. Examples include the pressure reducing/regulating valve and the air valve;

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The main components of a valve are the body or housing, which corresponds to the outer part. main body, in which all other components are installed, the castle, which is the body's cover, and from where the internals of the valve are accessed, the connection, which is the element through which the valve is connected to the piping or equipment and the valve obturator, which is the internal element. responsible for the valve's function (SILVA, OJL **Industrial Valves).**

The main means of operating a valve are (SILVA TELLES, PC **Piping)**
Industrial – Materials, Design, Assembly):

- Manual operation, which occurs through a steering wheel or levers and by intervention. Operator's manual. The use of a reduction gearbox is necessary for large valves. or that operate at high pressures, to facilitate handling of the device.
- Motorized operation occurs with the use of auxiliary operating systems. It is usually a pneumatic, hydraulic, or electrical system.
- Automatic operation, which occurs by means of springs or counterweights or by employing The fluid itself, taking advantage of pressure differences in the system;

2.5.1 Check valve

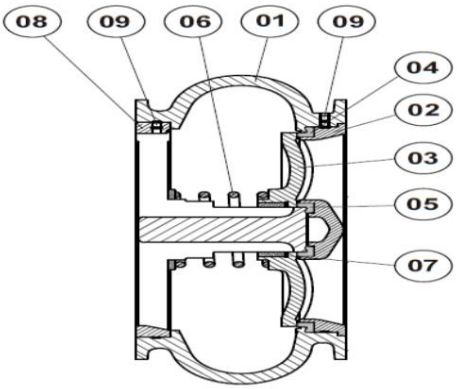
These are self-operating valves (also called automatic valves) due to The difference between the pressure exerted by the fluid upstream and downstream of the device. They are used to prevent backflow. It is recommended that check valves be installed in such a way that gravity tends to close them. They are used for various fluids, such as various gases, air, steam, and liquids that do not contain solid particles. in suspension. There are several types of check valves, such as the foot valve, which can have an associated strainer, a swing check valve, a piston check valve or sphere, which may be associated with a spring, and the double-door check valve, or The shutter is split in two, always associated with a spring, functioning like a hinge. The shutter of A double-door check valve closes before flow reversal can occur. This It can be used to protect the pump from hydraulic transients (SILVA, OJL **Valves) . Industrialists).**

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Figure 10 – Quick-closing double-door check valve



Item	Denominação	Material	Qtd
09	Parafuso allen s/cabeça	Aço carbono	04
08	Guia do Obturador	ASTM A536 Gr. 65.45.12	01
07	Bucha	Bronze SAE 40	01
06	Mola	Inox AISI 302	01
05	Sede menor	Poliuretano	01
04	Sede maior	Poliuretano	01
03	Obturador	ASTM A536 Gr. 65.45.12	01
02	Suporte da sede	ASTM A536 Gr. 65.45.12	01
01	Corpo	ASTM A536 Gr. 65.45.12	01

Source: Bermad Valloy

2.5.2 Butterfly valve

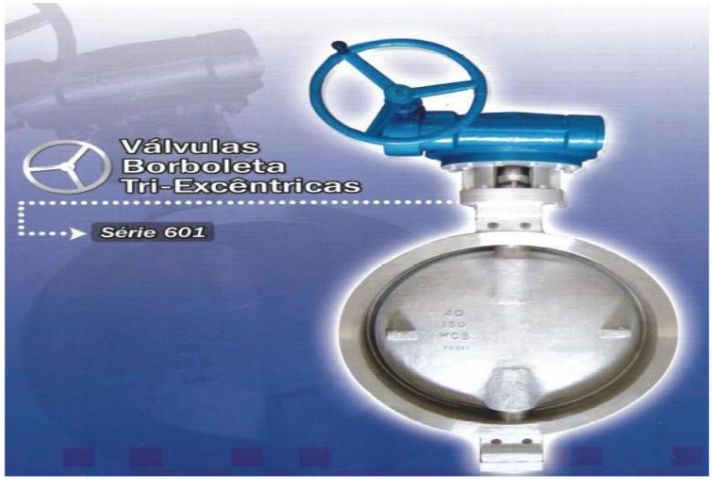
Butterfly valves can operate as regulating valves and as control valves.
The valve obturator is disc-shaped and rotates around an axis.
diametrically perpendicular to the fluid flow. This disc rotates so that the valve is
Closed or open. Butterfly valves can be used for liquid piping and
Large diameter gases at moderate pressure and temperature. A special case of valves.
Butterfly valves are of the triple-eccentric type, where the shutter is eccentric in relation to the axis.
diametrically and in relation to the center of the piping. Triple eccentric butterfly valves have
They offer superior sealing compared to conventional valves and, if used with metal seats, can...
working in pressure classes up to 600# (SILVA TELLES, PC **Industrial Piping – Materials, Design, Assembly).**

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Figure 11 – Triple eccentric butterfly valve with handwheel and reduction gearbox

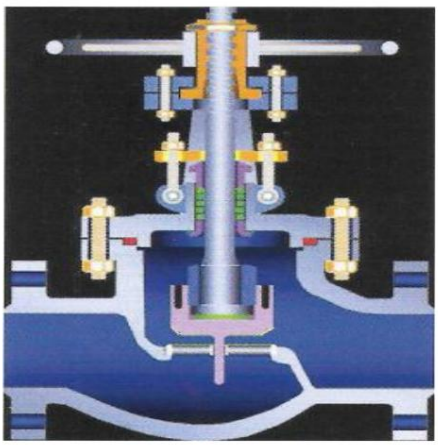


Source: Niagara

2.5.3 Globe valve

Globe valves are used for flow control, with opening and closing in...
any desired grade, of fluids such as water, oils, vapors and gases, across a wide range of
Temperature and pressure, allowing for complete sealing. Maintenance of this type of valve
This can be done without removing the housing from the line. The disadvantages of globe valves are...
relatively high pressure drop and not allowing flow in both directions. The shutter can
to be of the flat, spherical, conical, guided and needle type (SILVA, OJL **Industrial Valves).**

Figure 12 – Standard globe valve



Source: Industrial Valves

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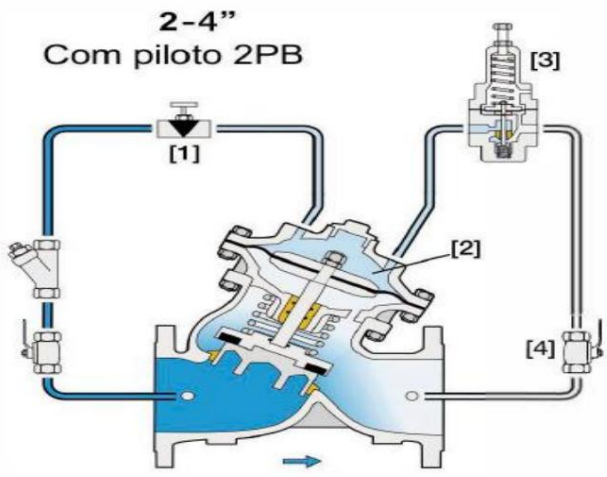
2.5.4 Downstream pressure control valve

Control valve is a generic term that designates a wide variety of valves. This
The type of valve is defined by always having an actuator, which can be pneumatic, hydraulic, or electric, which directly controls the shutter, and by the characteristic of being controlled by distance. The valve body is usually similar to that of a globe valve, as the effort less is needed for the operation and the ease of control is greater (SILVA TELLES, PC **Industrial Piping – Materials, Design, Assembly.**

The flow of fluid through the valve is clearly a function of the opening of the control valve. When the fitting is fully closed, the flow is zero, and when the valve is fully closed... At the open end, the flow is at its maximum. In intermediate positions, the flow percentage may be higher or lower. less than the percentage of opening, depending on the control valve model. For to allow for the correct selection and sizing of control valves, a number that The characteristic of the accessory was defined and named CV. The CV of the control valve varies in function of the various characteristics of the internals of these valves (SILVA, OJL **Valves) Industrialists).**

Downstream pressure regulating valves are valves that maintain downstream pressure within the established limits. within pre-established limits. These valves are automatic, often through valves pilot valves, components of the main valve, and actuated by the pressure of the fluid itself, giving or not passage to flow (SILVA TELLES, PC **Industrial Piping – Materials, Design, Assembly).**

Figure 13 – Downstream pressure control valve



Source: Bermad Valloy

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2.6 Instrumentation used in Industry

The purpose of instrumentation is the automatic measurement, regulation, command, and control of...
Industrial processes, alarm and protection systems, and automation systems. It enables a
reduction of operational labor and an improvement in the accuracy and quality of control of
processes. After measuring physical parameters of the process, such as pressure, temperature,
Flow rate, level, density, humidity, flow velocity, and other factors are all controlled by a regulating system.
A comparison with a pre-established value transmits a signal with the difference in measurement.
corresponding to a final element (FERNANDES, PST **Industrial Assemblies:**
Planning, execution and control).
The simplest device for measuring pressure is the piezometric tube, which consists of a tube.
A transparent tube is inserted into the pipe where pressure is to be measured. The liquid will rise in the
piezometric tube to a certain height that corresponds to the internal pressure. It is important that the
The piezometric tube must have a diameter greater than 10 mm so that capillary effects are achieved.
negligible. However, in practice, the most commonly used device for measuring pressure is the
Bourdon metal pressure gauge. All these devices indicate a relative value, which is
referring to local atmospheric pressure (AZEVEDO NETTO, JM **Manual of Hydraulics).**
Flow meters generally operate by measuring the pressure drop of the fluid in the piping.
known, or by means of an obstacle placed in it, such as orifice plates, venturis,
nozzles, Pitot tubes and rotameters (FERNANDES, PST **Industrial Assemblies:**
Planning, execution and control).

3 RESEARCH METHODOLOGY

This research is developed according to the methodology adopted for the preparation of a study of
This chapter will provide some details that will make it possible to understand and use the...
The results of this work, as reported by the readers.
The choice of research type considered Yin's (2001) proposal, in which the case study
The research should focus on the fair and rigorous presentation of empirical data.
collected.

For Yin (2001):

If you needed to know "how" or "why" the program worked (or didn't work), you would have to drive-
whether for a case study or for a field experiment. (Yin, 2001, p.26)

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

This work aims precisely to answer "how" and "why" the program (or project)
Developed with a singular objective, it worked.
The case study can follow a research strategy where the object of study is unique or
Multiple. Both types of case study strategy can be used for hypotheses.
generalized and for theoretical propositions, in such a way that the author of the work will not be able to
The objective is to enumerate the frequency of occurrence of a given object of study. The work
Research conducted as a type of case study is not limited to the study strategy.
qualitative, and can be used for quantitative studies and even for work that
They combine quantitative and qualitative evidence.
The quality of the work produced should be measured based on tests described by authors who...
have studied in sufficient depth the appropriate tactics for these measurements.
For the quality of the case study to be satisfactory, contradicting what researchers
Inexperienced people tend to assume that data collection needs to be done by a professional.
experienced and competent, so that vices and errors are not committed in this collection, in
function of procedures that follow pre-established biases and tendencies set by the collector of
data, so that opportunities that arise during the research can be taken advantage of.
The data-collecting researcher must have certain well-developed characteristics.
The professional should be inquisitive, independent, and make decisions based on the data available to them.
being collected.

According to Yin (2001), there are six main sources of data or evidence during a data collection process.
data that are:

- Documents;
- Records in files;
- Interviews;
- Direct observation;
- Participant observation;
- Physical artifacts.

A case study can benefit from just one of these data sources, or from two or more.
The processing strategy for all collected data should follow best principles.
described by important authors, as the incorporation of the principles that guide this
Processing will improve the quality of the work.
The analysis of the collected data should be conducted by the researcher using a strategy.
that establishes the main evidence to be categorized in tables, and the reasons for this.
The choices must be very well understood, so that the initial propositions of the studies...
These should be verified, and a well-dimensioned generalization should be proposed.

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Several techniques have been developed to organize the data, aiding in the analysis.
Data manipulation, while potentially useful in resolving certain problems, can be beneficial.
As a result of the investigation, these actions must be carried out with great care so that the results are not...
whether they are masked or affected by some bias on the part of the researcher.
The goal of analyzing the evidence should always be to treat the data honestly, so that
that the conclusions cannot be refuted. Alternative interpretations should also be considered.
eliminated, so that the research has a quality result.
The case study report will require a certain number of hours to prepare and is the
Conclusion of the work. It can be prepared in writing or orally, and does not need to follow a set format.
no pre-established form. However, it should always take the target audience as a reference.
The work should be written in a clear and engaging style that encourages the reader to continue reading.

RESULTS ANALYSIS

Brazil has the largest hydrological reserve in the world, with approximately 12% of the world's reserves.
The planet's freshwater. Of this freshwater, approximately 70% is in the Northern region, and 15% in the Southern region.
The Central-West region accounts for 6%, the Southeast region 6%, the South region 6%, and the Northeast region 3%. The abundance
The amount of water in the country is truly remarkable and is used for the production of electricity in
hydroelectric power plants, for the agro-industry, irrigating arable areas and providing feed for livestock.
It supplies animals and Brazilian cities and the population. A portion of this water is
also used by the manufacturing industry in general.
But the abundance of water in the country is not equally distributed. As is well known, the region of
The Caatinga region in the Northeast suffers from a lack of water for much of the year. The north and the
Northwest of the state of Minas Gerais also has problems with water shortages, despite...
relatively less severe than those in the Caatinga region.
The city of Paracatu, in the northwest of the state of Minas Gerais, is one of the cities in Brazil where
The abundance of water resources is not perceived. With rainfall levels close to
With a rainfall of 1300 mm per year, there have already been problems with water shortages in the city during those months.
The most critical periods correspond to the months of June, July, and August. In the most affected years, the
The water crisis in the city of Paracatu extended into November.
Paracatu was founded in the first half of the 18th century, with a strong vocation for mining.
In the first century of its existence, gold could be found in alluvial deposits in various
streams in the municipality. To this day, the city still has reserves of gold, limestone,
Zinc and lead.

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Another important economic activity in the city of Paracatu is agriculture and livestock farming. The city has More than 40,000 hectares of irrigated land, with mechanized production of corn, beans, and soybeans. It also produces coffee, cotton, and some fruits.

All these economic activities consume the region's water resources, resources that They are no longer abundant. And all human activities that alter the regime, quantity, or... The quality of water in a body of water is subject to authorization.

The granting of water rights is one of the instruments of the National and State Water Resources Policy through which the Public Authority authorizes the user, under pre-established conditions, to use or carry out hydraulic interferences in water resources necessary for their activity, guaranteeing the right access to these resources is contingent upon water being a public good. The authorization is granted. regulated by Federal Law No. 9,433, of January 8, 1997, as well as by State Laws of each entity of the federation.

In general, environmental laws in Brazil are strict, as they should be, and also... In general, these requirements are met by users of water resources and by the companies that... They exploit the environment to generate wealth, jobs, and taxes for the nation.

Gold mining in Paracatu has been ongoing since its discovery, but it was only in 1987 that... being exploited professionally. A mining company was installed at the site known as Morro do Ouro, through modern techniques, has been generating wealth for the region and promoting human development gains for the local population.

Like all processing plants, one of the various resources used by mining and Gold metallurgy in Paracatu relies on water, which is a vital resource for the entire community. as it is also a resource that is not so abundant in the northwest region of Minas Gerais, solutions Creative solutions had to be developed to ensure the continued operation of the plant, mainly in recent years, when a severe water crisis took hold in the region.

The mining company held authorization to draw water from some of the city's streams, but... The permit required that a minimum volume of water follow the course of the stream. And at one point Due to a production stoppage caused by a lack of water, a project was conceived, implemented, and... operated, so that the plant could remain in operation.

The project that was conceived, implemented, and operated to ensure the operation of the gold processing plant in Paracatu consisted of the drilling, development, and interconnection of several artesian wells. each with the proper authorization. The pipeline that would connect all the artesian wells would end in an existing water pipeline that would need to be upgraded to pump the new flow rate. of water, originating from already granted streams and also from new sources of water resources, the artesian wells.

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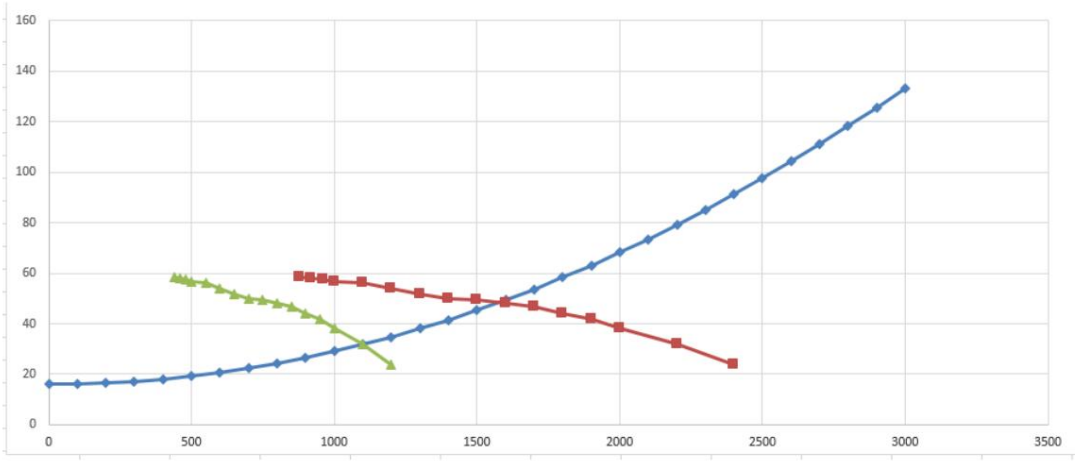
Several technological challenges were faced in order to achieve the project's success. Such as
The entire mining operation was paralyzed, one of the most important drivers of the project.
That was the deadline, but in this case study, the technical challenges will be the main points addressed.
The project under development should be able to capture water to ensure the continued operation of the
gold production plants, even though the volume of rainfall that occurred in Paracatu during the
The flow rate of the year was less than a certain value defined by the mining company's management.
The water flow from all the artesian wells drilled together should be greater than 1500 m³/h.
The first problem faced by the project team was defining the points of greatest...
probability of success. Site studies and geographical surveys were conducted on the location.
with the goal of identifying the most promising regions. However, this is not a science.
precise, and some wells proved unsuitable for use.
The plant has water intake systems in local streams, and the proposed solution...
Initially, the goal was to connect the various artesian wells that had been developed to the existing pipeline.
existing. However, calculations performed during the conceptual phase demonstrated that this
The solution would not be effective. This is because the combination of different pumps in
Depending on the system curve and consequently the operating point, parallel operation can...
This causes some pumps to operate in shut-off mode. Professor Archibald Joseph Macintyre, in his book PUMPS
AND PUMPING INSTALLATIONS, recommends avoiding pumps
different in parallel associations, to avoid secondary currents, in the sense that the
Higher-powered pumps should be installed before lower-powered pumps. Further study is recommended.
be aware of parallel connections in existing and long pipelines, since these are systems that
They have a pronounced curvature in the characteristic curve of the piping, a fact that reduces the gain of
increased flow rate worsens conditions for cavitation.
Conceptual dimensioning, used to refute the original idea of a well design project.
The calculation of the pressure drop in artesian wells connected to the existing pipeline was carried out using standard head loss formulas.
in piping, in addition to the bends of existing pumps. For new pumps for the wells.
Since this was a conceptual project without defined suppliers, the artesian wells were...
The original idea was evaluated based on characteristic curves of traditional suppliers.
considering the inclusion of 1 (one), 3 (three) and 9 (nine) artesian wells in the existing system. The
The graphs obtained from the project are shown below:

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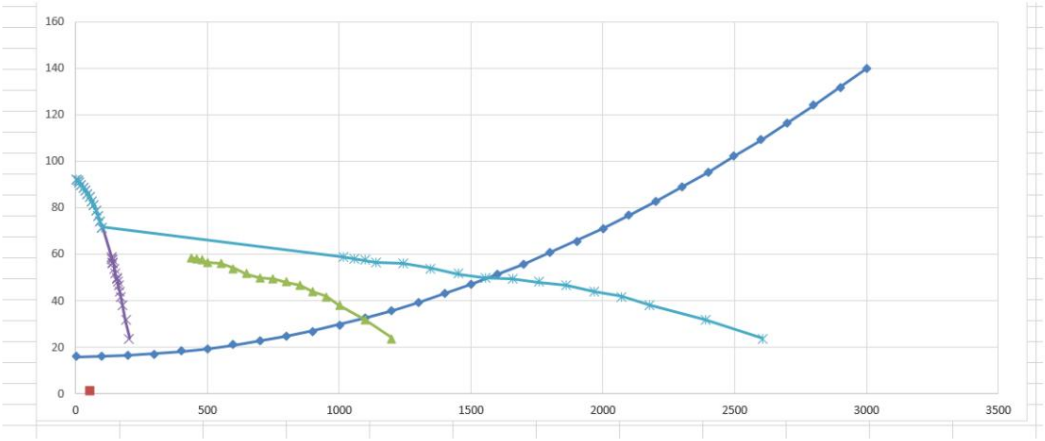
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Table 6 – Characteristic curve of existing equipment and system curve



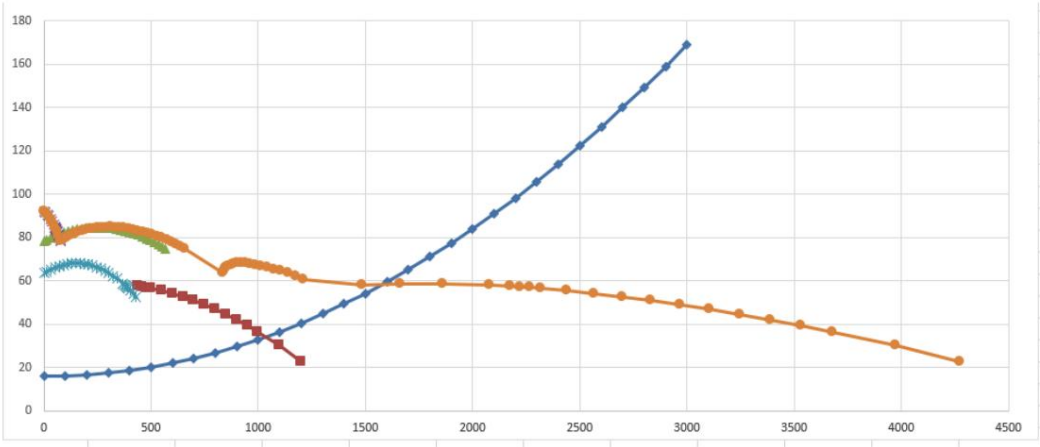
Source: Author's own elaboration

Table 7 – Characteristic curve of existing equipment associated with 1 artesian well and system curve



Source: Author's own elaboration

Table 8 – Characteristic curve of existing equipment associated with 3 artesian wells and system curve



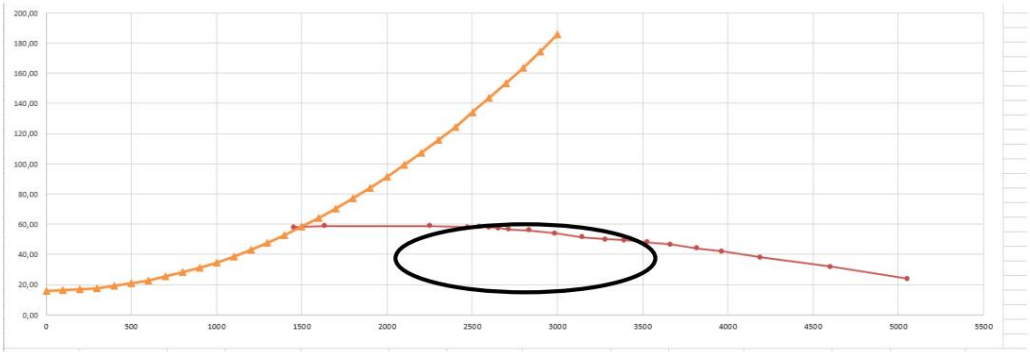
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Table 9 – Characteristic curve of existing equipment associated with 9 artesian wells and system curve



Source: Author's own elaboration

Without the addition of artesian wells, the existing system captures approximately 1600 m³/h.
With an artesian well connected to the existing system, a gain of [amount] was calculated.
approximately 56 m³/h. The system will therefore reach up to 1656 m³/h. With the combination of three
With artesian wells, the flow gain is only 9 m³/h compared to the gain obtained by...
Association of 1 artesian well. The expected flow rate with the addition of 3 wells associated with the
The existing system has a maximum flow rate of 1665 m³/h. With the combination of 9 wells, the pumps of
The existing intake will already be operating in "shutoff" mode, and consequently the flow rate will be equal to
Flow rate obtained without including any associated wells.
Based on these results, the mining company's management opted for a more alternative.
costly in terms of time and financial resources. A new pipeline should be installed, in which
All the artesian wells would be interconnected. The water from the artesian wells will be transported by...
a new pipeline, which will extend for approximately 6.2 km in length to the
existing water reservoir. The material of this piping will be HDPE and it will be a pipe
buried to a minimum depth of 1.2 meters.
Artesian wells, due to certain intrinsic characteristics, should not operate during
all day long; therefore, a flow rate slightly greater than 1500 m³/h should be achieved. The flow rate
The selected volume was 1580 m³/h.

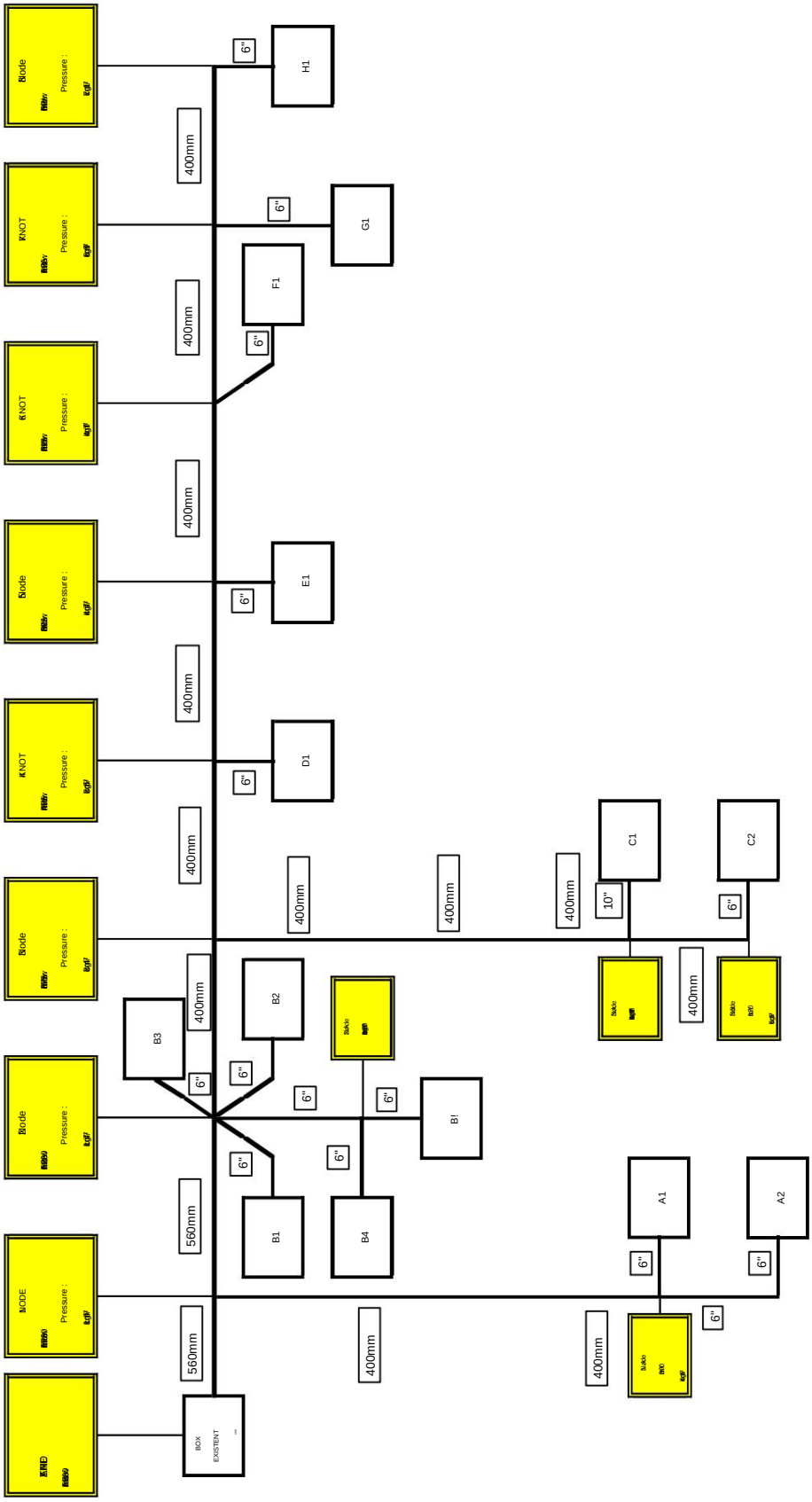
Below is the project flowchart, showing the pressure and flow rate results for each...
network node. Some information differs from the original design due to the fact that it is...
of strategic information for the company. However, the physics and mathematics that
The factors that enabled the project's success are replicated. The calculations were performed in a spreadsheet.
of electronic calculation, which was developed by the author of this work, and is represented in the appendices.
from this case study:

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Figure 14 – Project flowchart



Source: Author's own elaboration

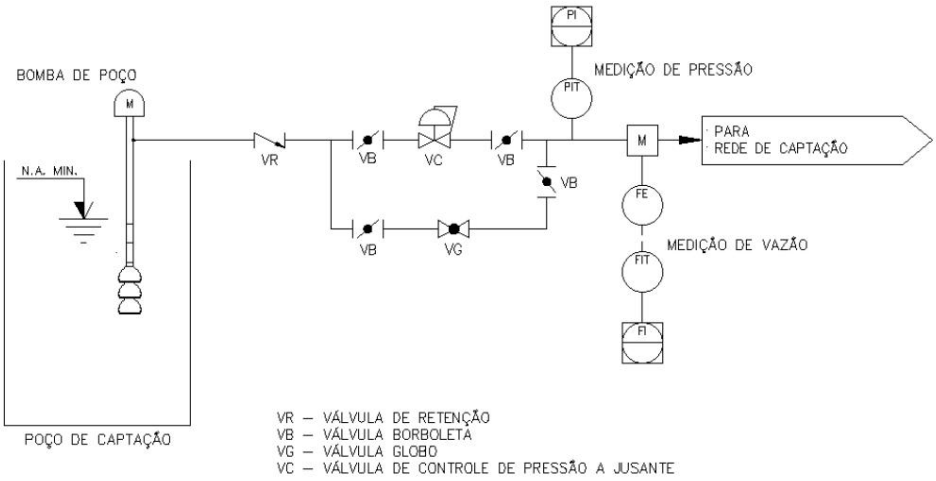
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For the project to succeed in capturing the necessary volume of water to meet its objectives...
As part of the project, valves were installed in the pipelines.
Butterfly valves were installed to allow for pipe shutoff and maintenance.
devices. A downstream pressure control valve was installed, which was responsible for
to allow a little more flow in each well, to supply the well that was in
recovery. A globe valve was installed in a bypass pipe to allow for
maintenance of the downstream pressure control valve itself. It was also installed, for each
well, a check valve.
To monitor the wells, additional necessary instruments were installed. Each well had...
a pressure gauge for local pressure measurement, a flow meter for accounting of
volume captured per well, and each well pump was controlled by an inverter.
frequency, which allowed for local operator intervention.
Below is a flowchart showing the valves and instruments:

Figure 15 – Flowchart of valves and instruments



Source: Author's own elaboration

CONCLUSIONS

With the completion of this work, it is possible to conclude that the project is viable from the point of view of...
From a technical standpoint, the implemented project operated as predicted in this study, and although
Some information and data may have been altered to maintain the trade secret of...
In a mining company, it is possible to replicate all stages of the process, following the same logic as...
mathematical and physical development.

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The use of downstream pressure control valves made it possible that, when necessary,
Shutting down one artesian well to allow water levels to recover will increase the flow of other wells.
Slightly increase the flow rate in the network to compensate for the lost flow. This entails the need for
point-to-point verification of equipment power, which, in the case of being too high,
Even when properly sized, the motors can be tripped due to overload.
The use of frequency inverters, which is not discussed much in this work, was a feature implemented in
The original design facilitated individual operator intervention in each well.
The captured flow rate met the project's requirements and is sufficient to maintain mine operations.
even in years of severe drought.
The table below shows the values for flow rate, pressure, upstream pipe diameter, and pipe diameter.
downstream pipes at each interconnection node of two or more connections:

Table 7 – Summary of results found at each pipe connection node

NODE	FLOW RATE m³/h	PRESSURE kgf/cm²	Upstream pipe ÿ Downstream pipe ÿ	
END	1580	0	560mm	-
1	1580	1.9	400mm/560mm	560mm
1A	300	4.1	2 x 6"	400mm
2	1280	1.7	4 x 6"/400mm	560mm
2A	150	2.8	2 x 6"	6"
3	875	3.4	2 x 400mm	400mm
3A	420	5.9	10"/400mm	400mm
3B	120	5.1	6"	400mm
4	455	3.5	6"/400	400mm
5	305	4.7	6"/400	400mm
6	215	4.7	6"/400	400mm
7	135	6.8	6"/400	400mm
8	50	7.1	6"	400mm

Source: Author's own elaboration

As we can see from the results of the connection nodes, the pressure in the network tends to
increase the water tank that receives the pumping from the wells to the beginning of the network, as it was
As expected. Some points do not follow this rule, due to the fact that the water tank is not...
at the highest point of the water network's topography.
Obviously, the flow rate decreases from the end to the beginning of the network, since each well increases...
More water in the catchment network.
Due to the decrease in flow rate from the beginning to the end of the network, it is possible to vary the diameter of the
piping, with the goal of reducing costs. The project opted to retain a large portion of the
main pipe and branch lines with unchanged pipe diameter, due to the large number

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

due to the uncertainties that this project had at the beginning of its activities. This premise remained until the End of implementation.

The table below shows the values for flow rate, manometric head, and well diameter.

reference pump model, number of rotors in series inside the pump body for

To enable the pumping and power required for the equipment's motor, per well:

Table 8 – Summary of results found for the specification of each pump for each well.

PIT	FLOW RATE m³/h	Hman mca	ÿ FROM THE WELL inches	PUMP STAGES	POWER	
A1	150	67	8	BHS 804	4	75
A2	150	66	8	BHS 804	4	75
B1	80	68	8	BHS 813	3	40
B2	80	59	8	BHS 813	3	30
B3	95	87	8	BHS 813	4	50
B4	65	81	6	BHS 517	8	40
B!	85	69	8	BHS 813	3	40
C1	300	121	12	BHS 12270	3	200
C2	120	123	8	BHS 813	5	100
D1	150	75	8	BHS 804	4	100
E1	90	103	8	BHS 813	4	75
F1	80	71	8	BHS 813	3	50
G1	85	93	8	BHS 813	4	50
H1	50	89	6	BHS 517	8	30

Source: Author's own elaboration

The results obtained for the well pumps do not follow a pattern, as is the case with the nodes.

of the connections. This is due to the fact that each well has a limited amount of water that can be extracted.

The water is captured and there is a different water level in the particular subsoil, and this difference causes the flow rate to vary.

and the manometric head of each pump is unique and unpredictable.

With all this data and results in hand, it was possible to specify and purchase all the...

The equipment, piping, valves, and instruments that made this project a success.

achieving the company's objectives.

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

APPENDICES

APPENDIX A1 – CALCULATION MEMORANDUM FOR THE WATER INTAKE NETWORK

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CÁLCULO DA PRESSÃO NA TUBULAÇÃO ATÉ O NÓ 1

1. Dados de entrada

Fluido	**Água bruta**	
Vazão	**1580,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,529	m
Diâmetro de recalque adotado	**0,4776**	m
Velociddes para ϕ adotados no recalque (m/s)	2,45	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
560	**PN12,5**	**PE100**	**41,2mm**

4. Cálculo da perda de carga

Número de Reynolds	1310899	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,011163476	
Comprimento da linha	970	m

Perda de carga localizada

Acessórios	Quantidade	L/D	Total
Curva 90	3	30	90
Curva 45	6	16	96
Valvula gaveta	1	8	8
Medidor de vazão	1	350	350

Comprimento equivalente	259,81	m
Comprimento Equivalente total	1229,81	m
Perda de carga na tubulação principal para este trecho	**8,80**	mca
Desnível geométrico desde a conexão até o próximo nó	**10,00**	m
PR - Pressão residual	0,00	mca
Pressão no nó da conexão com o próximo trecho	**18,80**	mca

Cálculos para o poço A1

1. Dados de entrada - Nó 1.A

Fluido	**Água bruta**	
Vazão	**300,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,230	m
Diâmetro de recalque adotado	**0,3412**	m
Velociddes para ϕ adotados no recalque (m/s)	0,91	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga

Número de Reynolds	348408	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,014025184	
Comprimento da linha	674	m

Perda de carga localizada

Acessórios	Quantidade	L/D	Total
Curva 45	7	16	112

Comprimento equivalente	38,21	m
Comprimento Equivalente total	712,21	m
Perda de carga na tubulação principal para este trecho	**1,24**	mca

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Desnível geométrico desde a conexão até o próximo nó	**21,00**	m
PR - Pressão residual	18,80	mca
Pressão no nó da conexão com o poço	**41,04**	mca

Cálculos da pressão necessária para vencer as perdas no recalque do poço

5. Dados de entrada - Poço A1

Fluido	**Água bruta**	
Vazão mínima	**150,0**	m³/h
Fator de projeto		
Vazão	**150,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

6. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,163	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	2,24	m/s

7. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

8. Cálculo da perda de carga

Número de Reynolds	385764	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,016874149	
Comprimento da linha	25,00	m

Perda de carga localizada:

Acessórios	Quantidade	L/D	Total
Curva 90	2	30	60
Curva 45	4	16	64
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	97,07	m
Comprimento Equivalente total	122,07	m
Perda de carga na tubulação do recalque deste poço	**3,41**	mca
Desnível geométrico desde a conexão até o próximo nó	**0,00**	mca
Nível dinâmico do poço	22,94	m
Pressão sem contar a pressão da tubulação principal	**26,35**	mca

Definição do equipamento empregado no poço

9. Altura manométrica total calculada para a bomba deste poço

Pressão no nó da conexão com o poço	**41,04**	mca
Pressão sem contar a pressão da tubulação principal	**26,35**	mca
Hman Total	**67**	mca

10. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

11. Seleção da bomba

11.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	150	m³/h
Pressão por bomba	67	mca

11.2. Bomba selecionada

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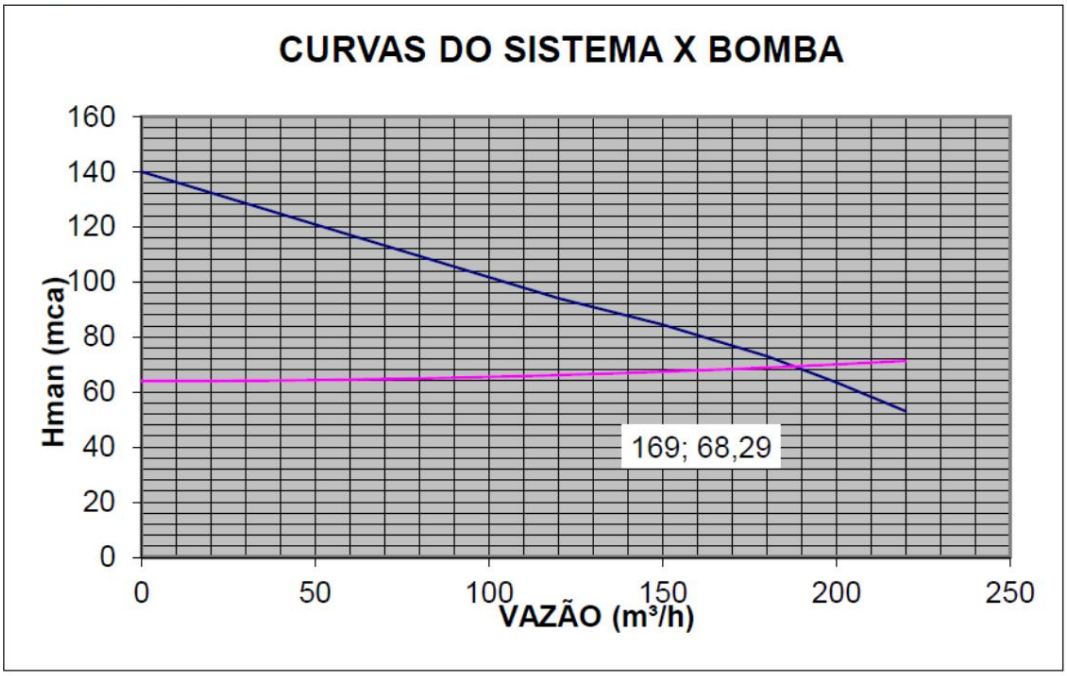
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Fornecedor	EBARA	
Modelo	BHS 804	
Rendimento	63	%
NPSH requerido	5,9	mca
Quantidade de estágios	4	

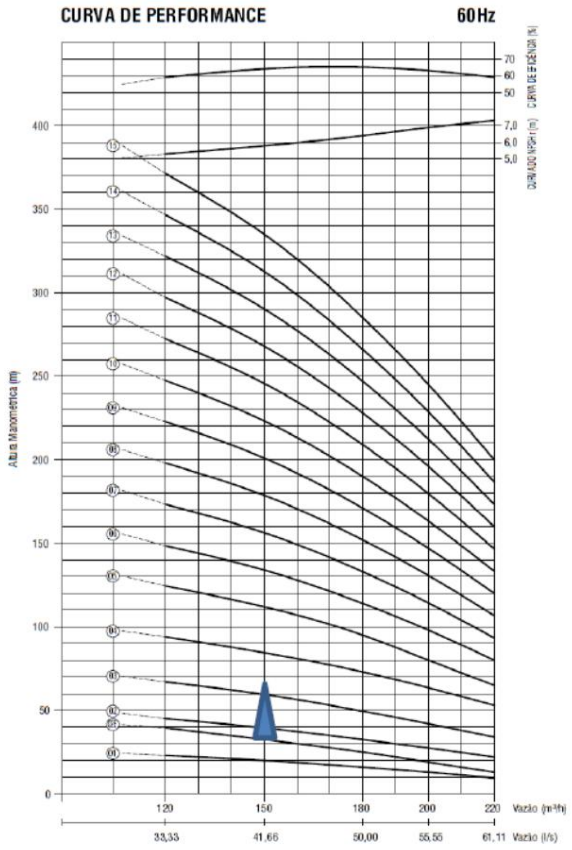
11.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	59,32	cv
Rendimentos mecânicos:	88%	
Potência do motor:	67,16	cv
Motor adotado:	75	cv

12. Curvas do sistema



13. Curva do fabricante



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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Cálculos para o poço A2

1. Dados de entrada - Poço A2

Fluido	**Água bruta**	
Vazão	**150,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,163	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	2,24	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	385764	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,016874149	
Comprimento da linha	91	m

Perda de carga localizada

Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	180,98	m
Perda de carga na tubulação principal para este trecho	**5,05**	mca
Desnível geométrico da tubulação individual do poço	**0,00**	m
PR - Pressão residual	41,04	mca
Nível dinâmico do poço	20,15	m
Pressão no nó da conexão com o poço	**66,24**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	20,15	mca
Hr - Perda de carga no recalque	5,05	mca
PR - Pressão residual	41,04	mca
Hman Total	**66**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	150	m³/h
Pressão por bomba	66	mca

7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 804	
Rendimento	63	%

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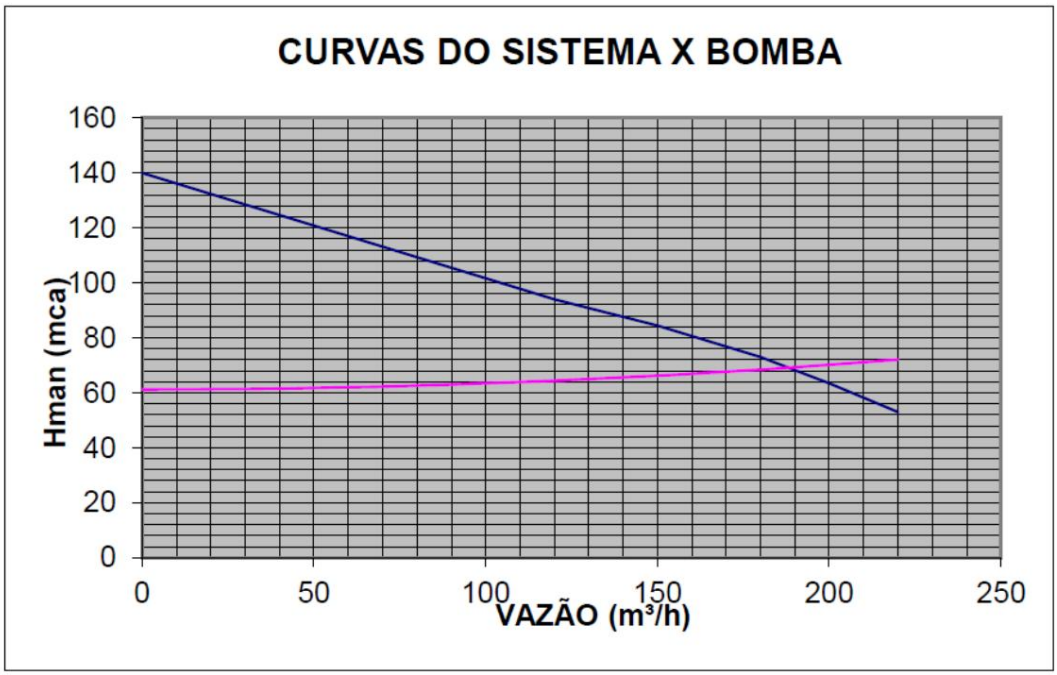
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NPSH requerido	5,9	mca
Quantidade de estágios	3	

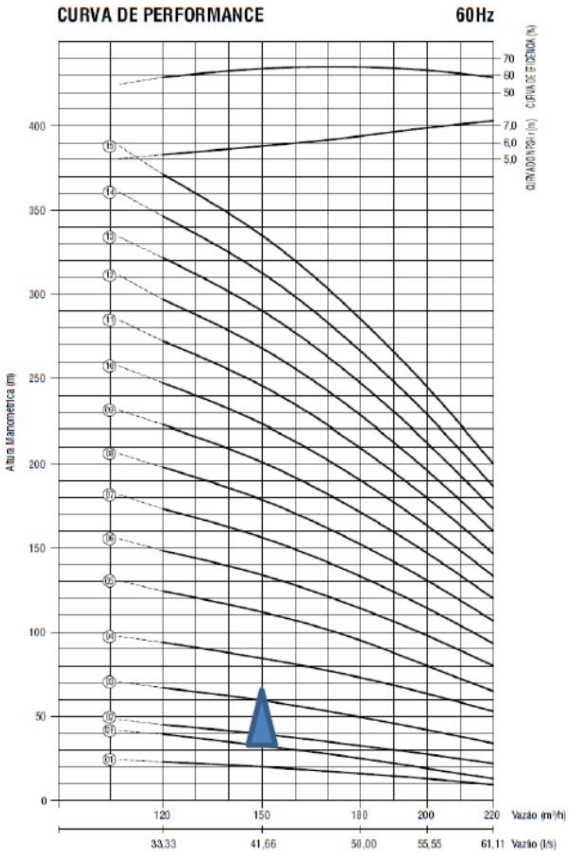
7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	58,31	cv
Rendimentos mecânicos:	88%	
Potência do motor:	66,02	cv
Motor adotado:	75	cv

8. Curvas do sistema



9. Curva do fabricante



CÁLCULO DA PRESSÃO NA TUBULAÇÃO ATÉ O NÓ 2

1. Dados de entrada

Fluido	Água bruta

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Vazão	**1280,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,476	m
Diâmetro de recalque adotado	**0,4776**	m
Velocidades para ϕ adotados no recalque (m/s)	1,99	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
560	**PN12,5**	**PE100**	**41,2mm**

4. Cálculo da perda de carga

Número de Reynolds	1061994	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,011550804	
Comprimento da linha	710	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	2	30	60
Curva 45	5	16	80

Comprimento equivalente	66,86	m
Comprimento Equivalente total	776,86	m
Perda de carga na tubulação principal para este trecho	**3,78**	mca
Desnível geométrico desde a conexão até o próximo nó	**-6,00**	m
PR - Pressão residual	18,80	mca
Pressão no nó da conexão com o próximo trecho	**16,58**	mca

Cálculos para o poço B1

1. Dados de entrada - Poço B1

Fluido	**Água bruta**	
Vazão	**80,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,119	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	1,19	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	205741	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,017888297	
Comprimento da linha	60	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	149,98	m
Perda de carga na tubulação principal para este trecho	**1,26**	mca

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ISSN: 2675-9128. São Paulo-SP.

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Desnível geométrico da tubulação individual do poço	**3,00**	m
PR - Pressão residual	16,58	mca
Nível dinâmico do poço	47,00	m
Pressão no nó da conexão com o poço	**67,84**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	50,00	mca
Hr - Perda de carga no recalque	1,26	mca
PR - Pressão residual	16,58	mca
Hman Total	**68**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	80	m³/h
Pressão por bomba	68	mca

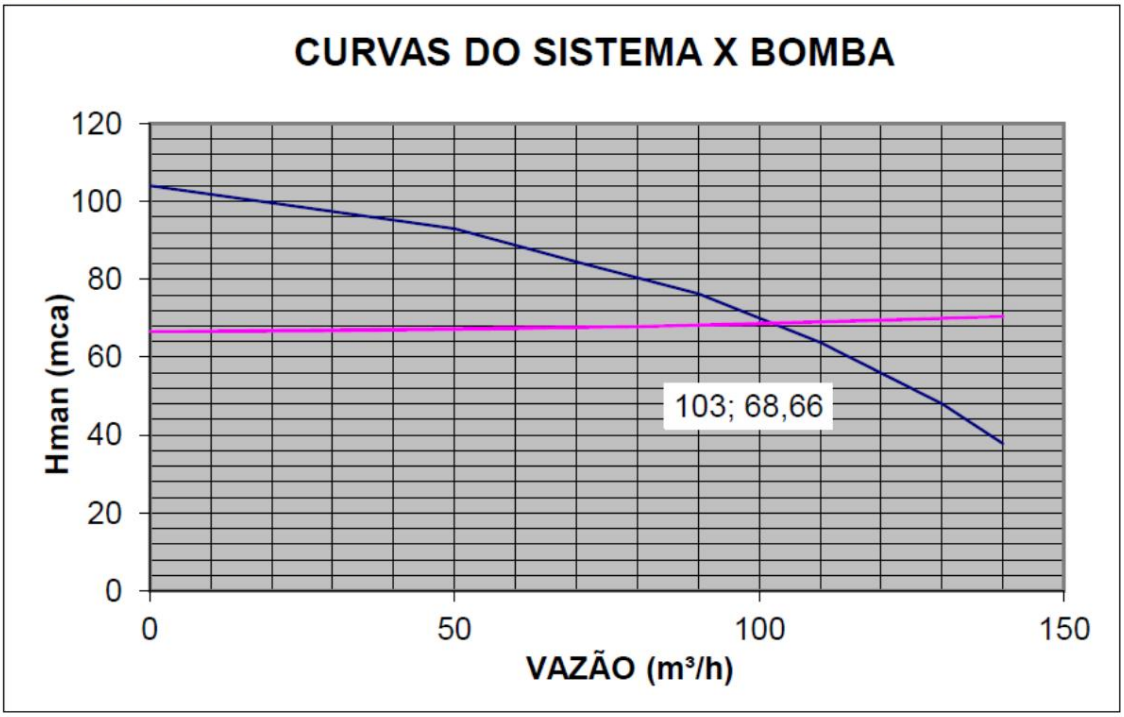
7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 813	
Rendimento	69	%
NPSH requerido	4	mca
Quantidade de estágios	3	

7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	29,08	cv
Rendimentos mecânicos:	88%	
Potência do motor:	32,92	cv
Motor adotado:	**40**	cv

8. Curvas do sistema

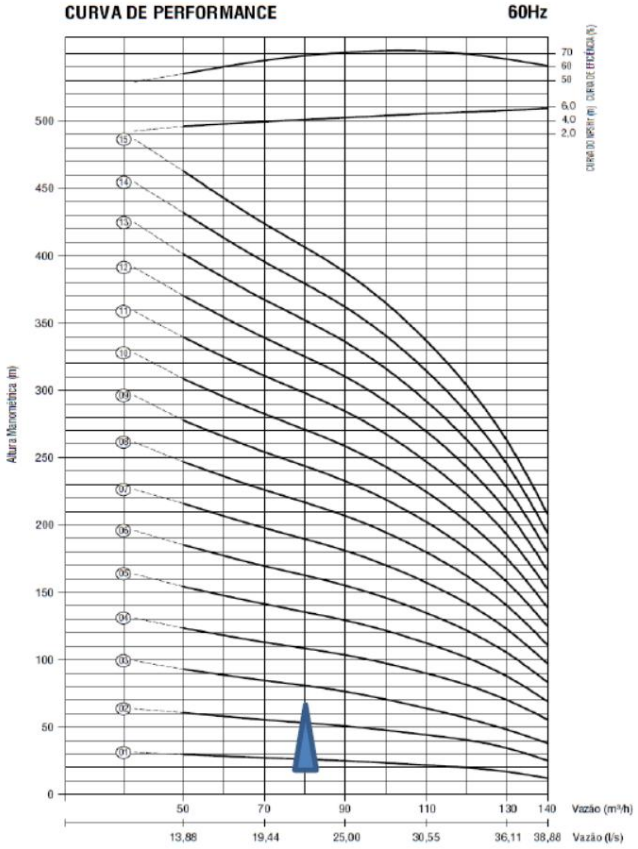


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RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

9. Curva do fabricante



Cálculos para o poço B2

1. Dados de entrada - Poço B2

Fluido	**Água bruta**	
Vazão	**80,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,119	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	1,19	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	205741	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,017888297	
Comprimento da linha	54	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	143,98	m
Perda de carga na tubulação principal para este trecho	**1,21**	mca

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Desnível geométrico da tubulação individual do poço	7,00	m
PR - Pressão residual	16,58	mca
Nível dinâmico do poço	34,00	m
Pressão no nó da conexão com o poço	**58,79**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	41,00	mca
Hr - Perda de carga no recalque	1,21	mca
PR - Pressão residual	16,58	mca
Hman Total	**59**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	80	m³/h
Pressão por bomba	59	mca

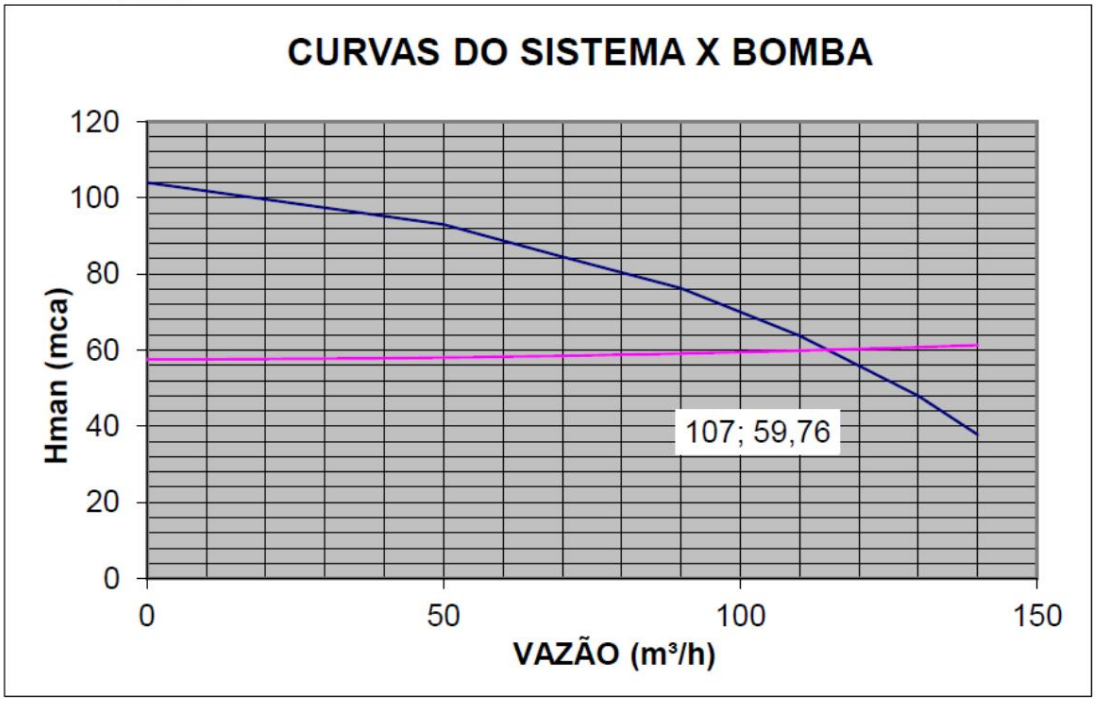
7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 813	
Rendimento	69	%
NPSH requerido	4	mca
Quantidade de estágios	3	

7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	25,20	cv
Rendimentos mecânicos:	88%	
Potência do motor:	28,53	cv
Motor adotado:	**30**	cv

8. Curvas do sistema

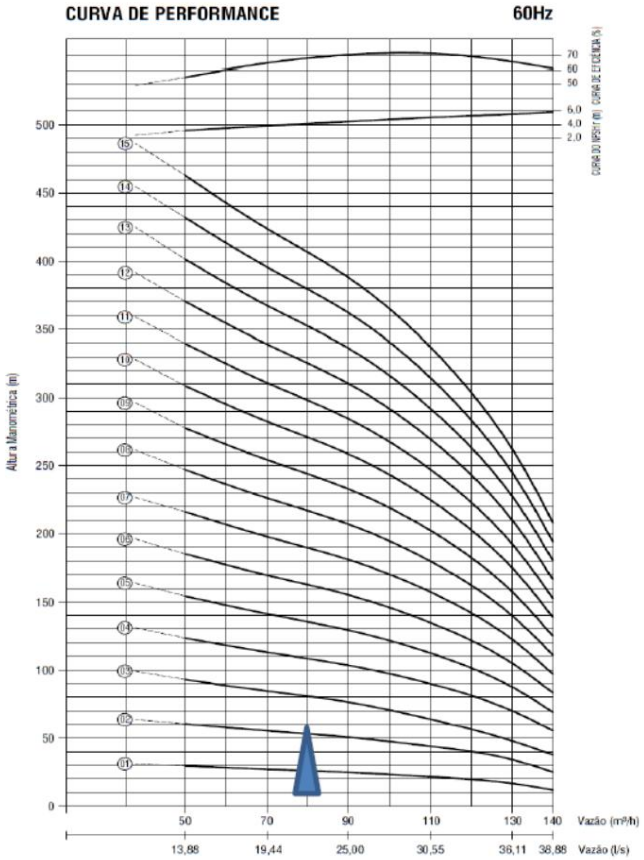


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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

9. Curva do fabricante



Cálculos para o poço B3

1. Dados de entrada - Poço B3

Fluido	**Água bruta**	
Vazão	**95,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,130	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	1,42	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	244317	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,017570259	
Comprimento da linha	58	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	147,98	m
Perda de carga na tubulação principal para este trecho	**1,72**	mca

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Desnível geométrico da tubulação individual do poço	**6,00**	m
PR - Pressão residual	16,58	mca
Nível dinâmico do poço	63,00	m
Pressão no nó da conexão com o poço	**87,30**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	69,00	mca
Hr - Perda de carga no recalque	1,72	mca
PR - Pressão residual	16,58	mca
Hman Total	**87**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	95	m³/h
Pressão por bomba	87	mca

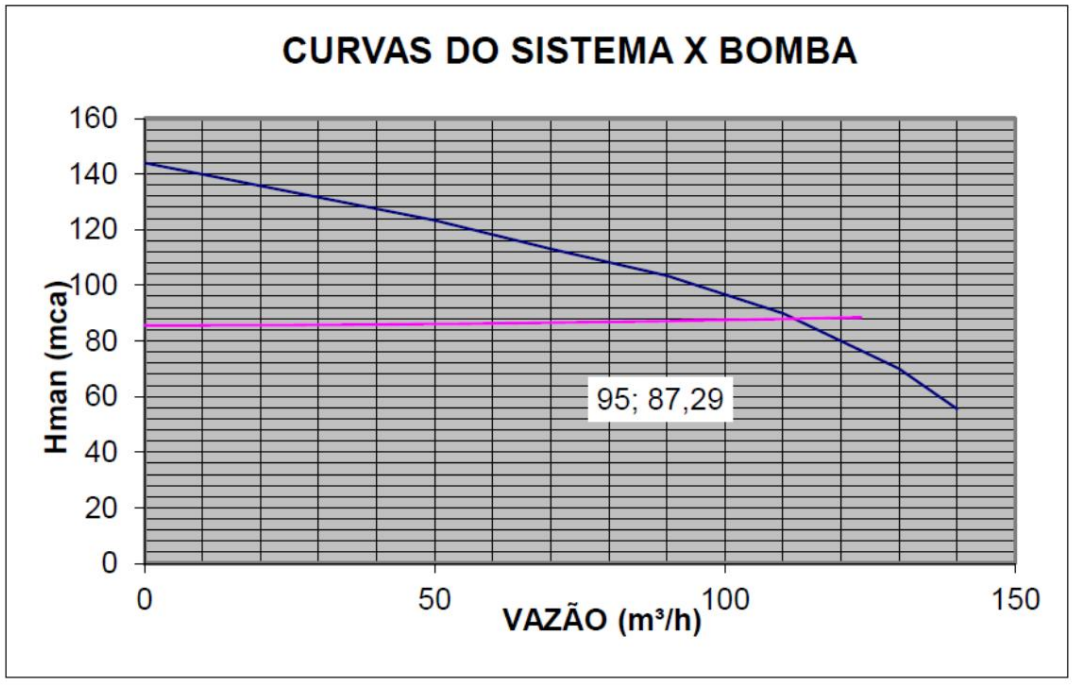
7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 813	
Rendimento	70,5	%
NPSH requerido	4,5	mca
Quantidade de estágios	4	

7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	43,49	cv
Rendimentos mecânicos:	88%	
Potência do motor:	49,24	cv
Motor adotado:	**50**	cv

8. Curvas do sistema

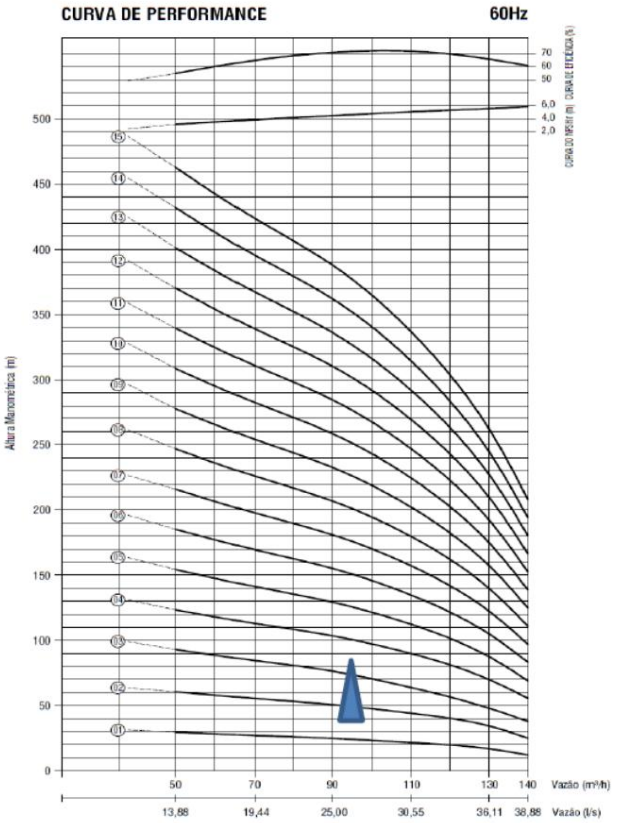


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Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

9. Curva do fabricante



Cálculos para o poço B4

1. Dados de entrada - Nó 2.A

Fluido	**Água bruta**	
Vazão	**150,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,163	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	2,24	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	385764	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,016874149	
Comprimento da linha	141	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	10	16	160

Comprimento equivalente	29,28	m
Comprimento Equivalente total	170,28	m
Perda de carga na tubulação principal para este trecho	**4,75**	mca
Desnível geométrico desde a conexão até o próximo nó	**7,00**	m
PR - Pressão residual	16,58	mca
Pressão no nó da conexão com o poço	**28,33**	mca

Cálculos da pressão necessária para vencer as perdas no recalque do poço

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5. Dados de entrada - Poço B4

Fluido	**Água bruta**	
Vazão mínima	**65,0**	m³/h
Fator de projeto		
Vazão máxima	**65,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

6. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,107	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	0,97	m/s

7. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

8. Cálculo da perda de carga

Número de Reynolds	167164	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,018318425	
Comprimento da linha	158,00	m

Perda de carga localizada:

Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	1	16	16
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	85,05	m
Comprimento Equivalente total	243,05	m
Perda de carga na tubulação do recalque deste poço	**1,38**	mca
Desnível geométrico desde a conexão até o próximo nó	**-4,00**	mca
Nível dinâmico do poço	55,00	m
Pressão sem contar a pressão da tubulação principal	**52,38**	mca

Definição do equipamento empregado no poço

9. Altura manométrica total calculada para a bomba deste poço

Pressão no nó da conexão com o poço	**28,33**	mca
Pressão sem contar a pressão da tubulação principal	**52,38**	mca
Hman Total	**81**	mca

10. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

11. Seleção da bomba

11.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	65	m³/h
Pressão por bomba	81	mca

11.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 517	
Rendimento	70,5	%
NPSH requerido	3,9	mca

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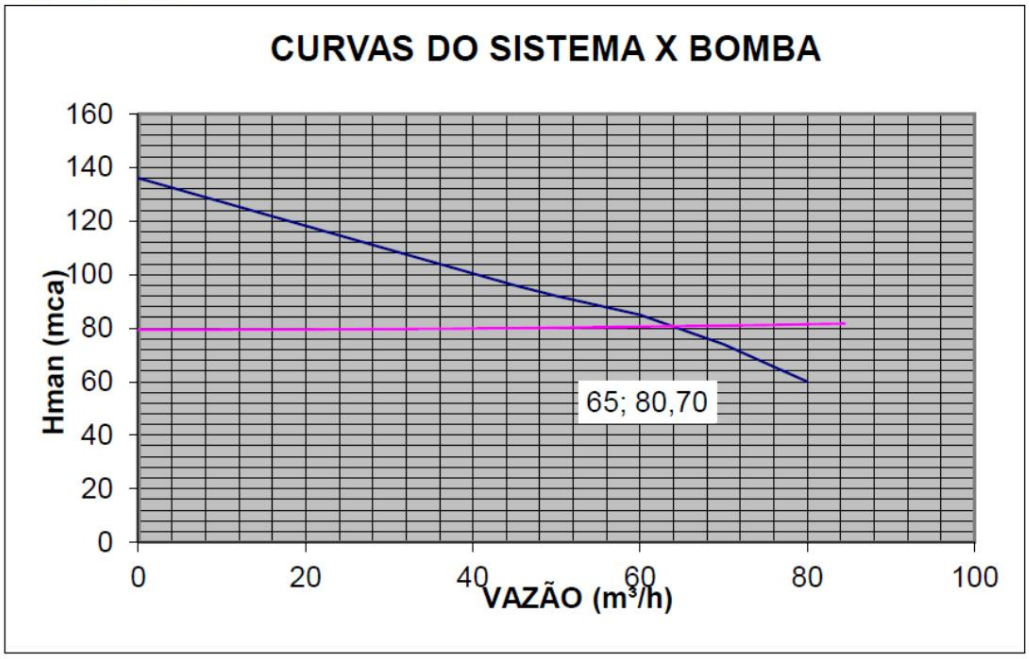
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Quantidade de estágios	6	

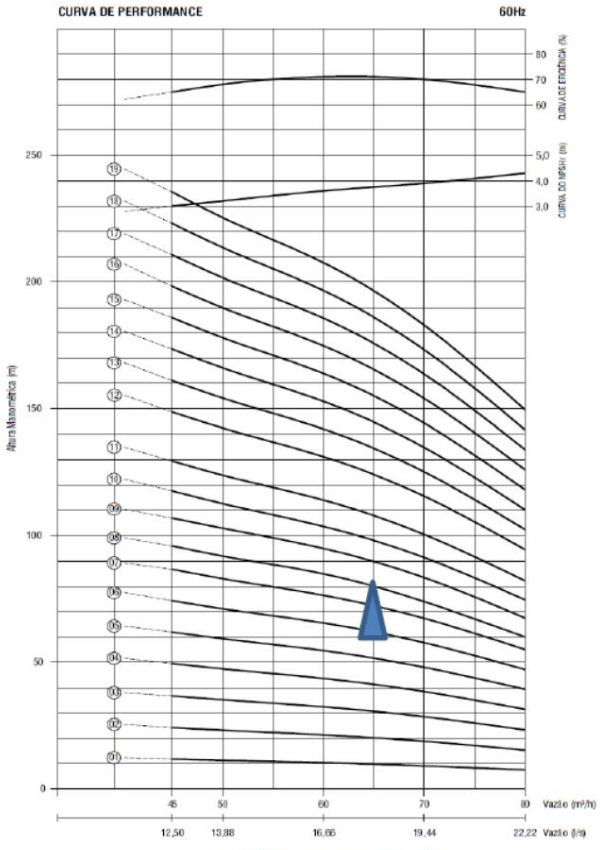
11.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	27,51	cv
Rendimentos mecânicos:	88%	
Potência do motor:	31,15	cv
Motor adotado:	**40**	cv

12. Curvas do sistema



13. Curva do fabricante



Cálculos para o poço B5

1. Dados de entrada - Poço B5

Fluido	**Água bruta**	
Vazão	**85,0**	m³/h

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,123	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	1,27	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	218599	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,017772313	
Comprimento da linha	39	m

Perda de carga localizada

Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	128,98	m
Perda de carga na tubulação principal para este trecho	**1,22**	mca
Desnível geométrico da tubulação individual do poço	**4,00**	m
PR - Pressão residual	28,33	mca
Nível dinâmico do poço	35,00	m
Pressão no nó da conexão com o poço	**68,55**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	39,00	mca
Hr - Perda de carga no recalque	1,22	mca
PR - Pressão residual	28,33	mca
Hman Total	**69**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	85	m³/h
Pressão por bomba	69	mca

7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 813	
Rendimento	69	%
NPSH requerido	4	mca
Quantidade de estágios	3	

7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	31,22	cv

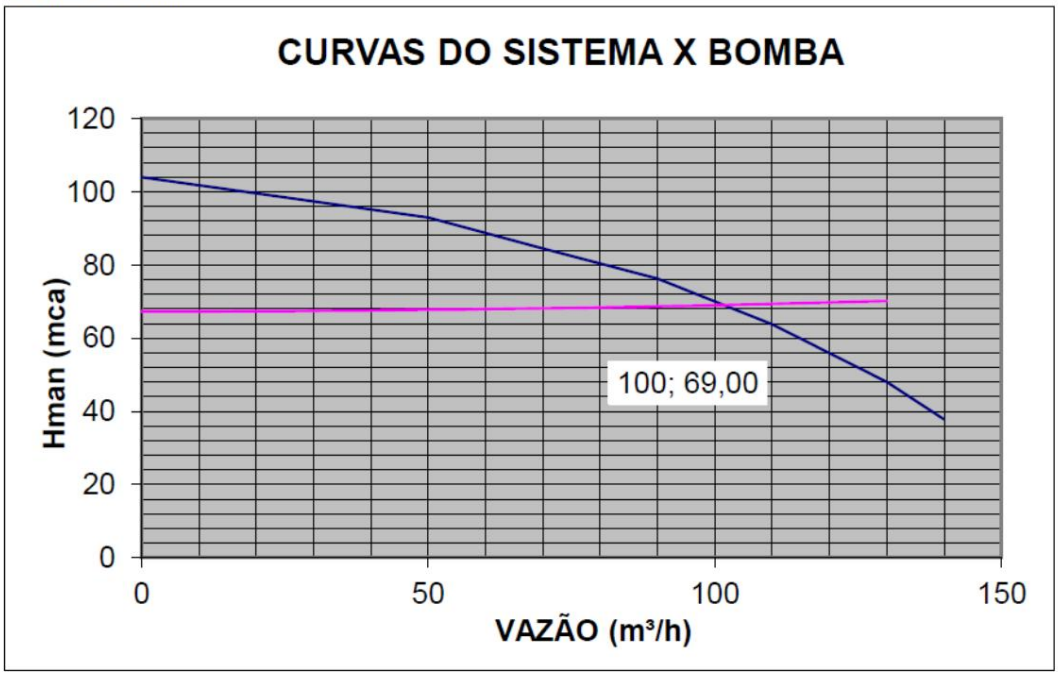
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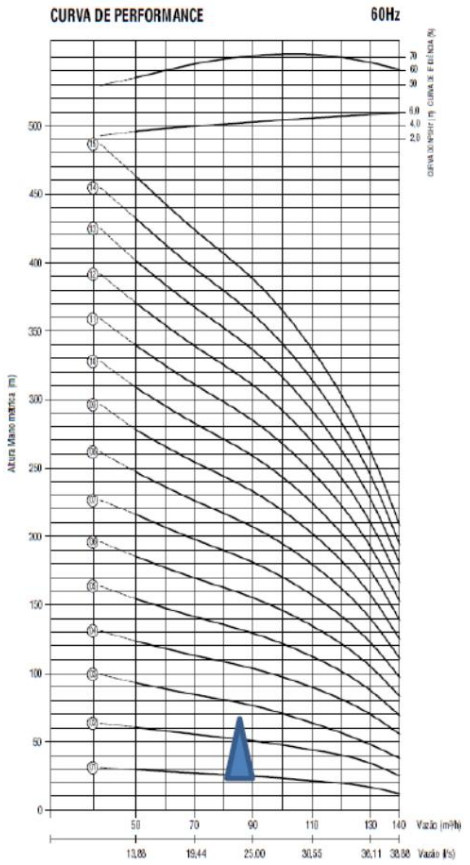
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Rendimentos mecânicos:	88%	
Potência do motor:	35,35	cv
Motor adotado:	40	cv

8. **Curvas do sistema**



9. **Curva do fabricante**



CÁLCULO DA PRESSÃO NA TUBULAÇÃO ATÉ O NÓ 3

1. **Dados de entrada - Tubulação principal**

Fluido	Água bruta	
Vazão	875,0	m³/h
Temperatura	25,0	°C
Viscosidade	8,93E-07	m²/s
Peso específico	0,998	t/m³

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2. Cálculo do diâmetro das tubulações - Tubulação principal

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,393	m
Diâmetro de recalque adotado	**0,3412**	m
Velociddes para ϕ adotados no recalque (m/s)	2,66	m/s

3. Tubulação selecionada - Tubulação principal

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga - Tubulação principal

Número de Reynolds	1016191	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,011655895	
Comprimento da linha	650	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	3	30	90
Curva 45	9	16	144

Comprimento equivalente	79,84	m
Comprimento Equivalente total	729,84	m
Perda de carga na tubulação principal para este trecho	**8,99**	mca
Desnível geométrico desde a conexão até o próximo nó	**8,00**	m
PR - Pressão residual	16,58	mca
Pressão no nó da conexão com o próximo trecho	**33,57**	mca

Cálculos para o poço C1

1. Dados de entrada - Nó 3.A

Fluido	**Água bruta**	
Vazão	**420,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,273	m
Diâmetro de recalque adotado	**0,3412**	m
Velociddes para ϕ adotados no recalque (m/s)	1,28	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga

Número de Reynolds	487772	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,013202769	
Comprimento da linha	1311	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	3	30	90
Curva 45	30	16	480

Comprimento equivalente	194,48	m
Comprimento Equivalente total	1505,48	m
Perda de carga na tubulação principal para este trecho	**4,84**	mca
Desnível geométrico desde a conexão até o próximo nó	**21,00**	m
PR - Pressão residual	33,57	mca
Pressão no nó da conexão com o poço	**59,41**	mca

Cálculos da pressão necessária para vencer as perdas no recalque do poço

5. Dados de entrada - Poço C1

Fluido	**Água bruta**	
Vazão mínima	**300,0**	m³/h
Fator de projeto		

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Vazão máxima	**300,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

6. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,230	m
Diâmetro de recalque adotado	**0,25446**	m
Velocidades para ϕ adotados no recalque (m/s)	1,64	m/s

7. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
10"	**sch40/std**	**ASTM A53GrB**	**9,27mm**

8. Cálculo da perda de carga

Número de Reynolds	467173	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,015572559	
Comprimento da linha	150,00	m

Perda de carga localizada:

Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	1	16	16
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	140,46	m
Comprimento Equivalente total	290,46	m
Perda de carga na tubulação do recalque deste poço	**2,44**	mca
Desnível geométrico desde a conexão até o próximo nó	**44,00**	mca
Nível dinâmico do poço	15,10	m
Pressão sem contar a pressão da tubulação principal	**61,54**	mca

Definição do equipamento empregado no poço

9. Altura manométrica total calculada para a bomba deste poço

Pressão no nó da conexão com o poço	**59,41**	mca
Pressão sem contar a pressão da tubulação principal	**61,54**	mca
Hman Total	**121**	mca

10. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

11. Seleção da bomba

11.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	300	m³/h
Pressão por bomba	121	mca

11.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS-12270	
Rendimento	81	%
NPSH requerido	10,5	mca
Quantidade de estágios	3	

11.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	165,60	cv
Rendimentos mecânicos:	88%	

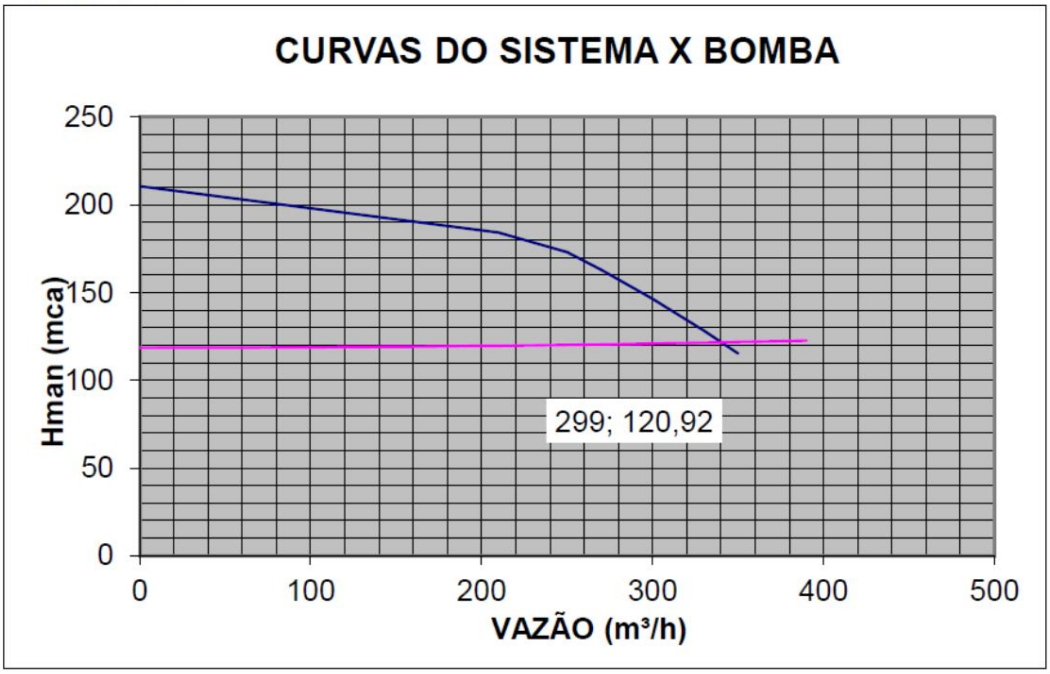
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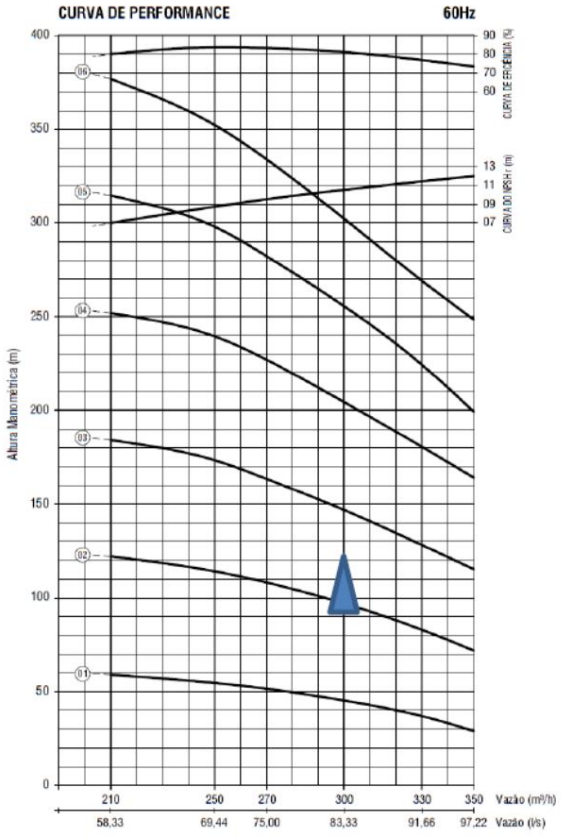
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Potência do motor:	187,50	cv
Motor adotado:	200	cv

12. Curvas do sistema



13. Curva do fabricante



Cálculos para o poço C2

1. Dados de entrada - Nó 3.B

Fluido	Agua bruta	
Vazão	120,0	m³/h
Temperatura	25,0	°C
Viscosidade	8,93E-07	m²/s
Peso específico	0,998	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	2,00	m/s
Diâmetro conforme velocidade econômica (m)	0,146	m

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Diâmetro de recalque adotado	**0,3412**	m
Velocidades para ϕ adotados no recalque (m/s)	0,36	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga

Número de Reynolds	139363	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,016718122	
Comprimento da linha	745	m

Perda de carga localizada

Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	10	16	160

Comprimento equivalente	64,83	m
Comprimento Equivalente total	809,83	m
Perda de carga na tubulação principal para este trecho	**0,27**	mca
Desnível geométrico desde a conexão até o próximo nó	**-9,00**	m
PR - Pressão residual	59,41	mca
Pressão no nó da conexão com o poço	**50,67**	mca

Cálculos da pressão necessária para vencer as perdas no recalque do poço

5. Dados de entrada - Poço C2

Fluido	**Água bruta**	
Vazão mínima	**120,0**	m³/h
Fator de projeto		
Vazão máxima	**120,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

6. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,146	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	1,79	m/s

7. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

8. Cálculo da perda de carga

Número de Reynolds	308611	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,017188701	
Comprimento da linha	67,00	m

Perda de carga localizada:

Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	1	16	16
Valvula borboleta	2	8	16
Valvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	85,05	m
Comprimento Equivalente total	152,05	m
Perda de carga na tubulação do recalque deste poço	**2,77**	mca
Desnível geométrico desde a conexão até o próximo nó	**0,00**	mca
Nível dinâmico do poço	70,00	m
Pressão sem contar a pressão da tubulação principal	**72,77**	mca

Definição do equipamento empregado no poço

9. Altura manométrica total calculada para a bomba deste poço

Pressão no nó da conexão com o poço	**50,67**	mca
Pressão sem contar a pressão da tubulação principal	**72,77**	mca
Hman Total	**123**	mca

10. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

11. Seleção da bomba

11.1. Definição da associação das bombas

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	120	m³/h
Pressão por bomba	123	mca

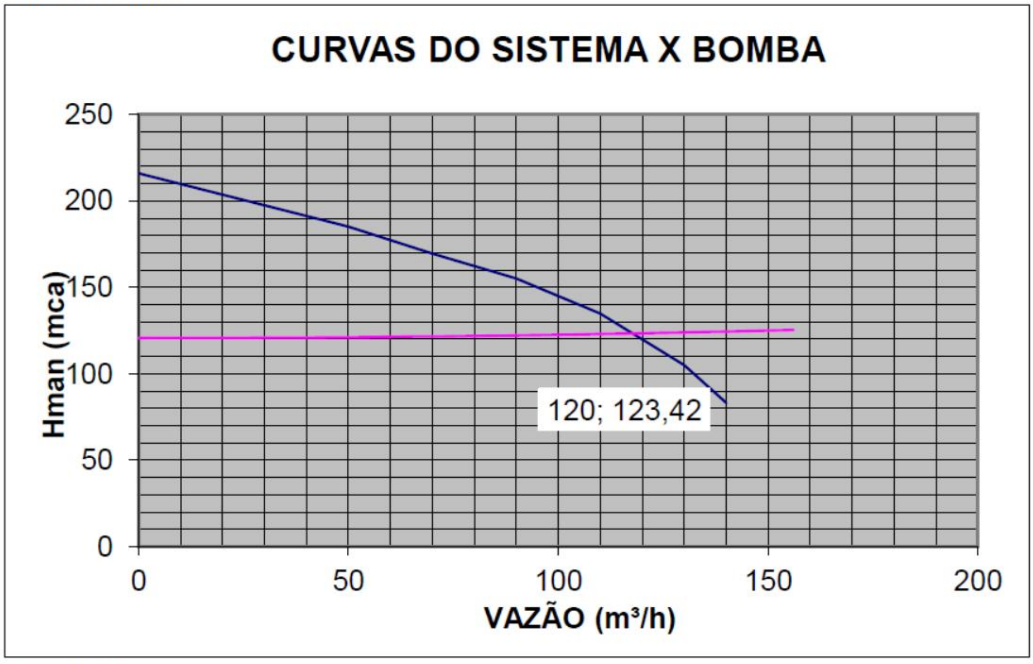
11.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 813	
Rendimento	70	%
NPSH requerido	5,5	mca
Quantidade de estágios	5	

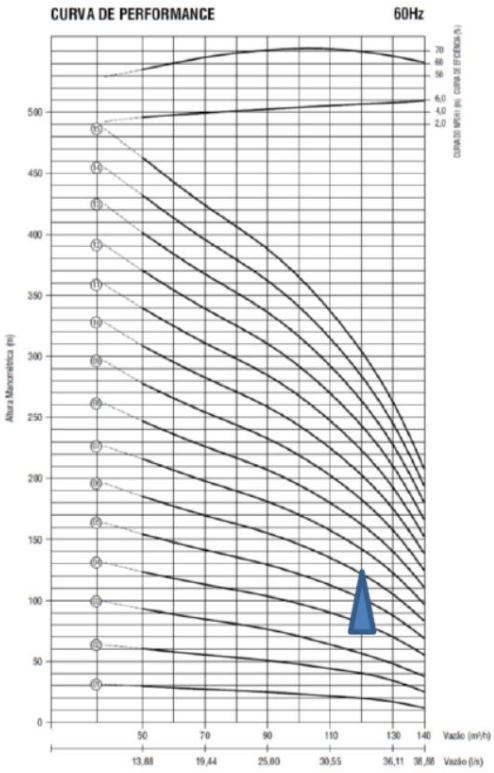
11.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	78,23	cv
Rendimentos mecânicos:	88%	
Potência do motor:	88,58	cv
Motor adotado:	**100**	cv

12. Curvas do sistema



13. Curva do fabricante



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CÁLCULO DA PRESSÃO NA TUBULAÇÃO ATÉ O NÓ 4

1. Dados de entrada - Tubulação principal

Fluido	**Água bruta**	
Vazão	**455,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações - Tubulação principal

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,284	m
Diâmetro de recalque adotado	**0,3412**	m
Velocidades para ϕ adotados no recalque (m/s)	1,38	m/s

3. Tubulação selecionada - Tubulação principal

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga - Tubulação principal

Número de Reynolds	528419	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,01301835	
Comprimento da linha	220	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	15	16	240

Comprimento equivalente	92,12	m
Comprimento Equivalente total	312,12	m
Perda de carga na tubulação principal para este trecho	**1,16**	mca
Desnível geométrico desde a conexão até o próximo nó	**0,00**	m
PR - Pressão residual	33,57	mca
Pressão no nó da conexão com o próximo trecho	**34,73**	mca

Cálculos para o poço D1

1. Dados de entrada - Poço D1

Fluido	**Água bruta**	
Vazão	**150,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,163	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	2,24	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	385764	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,016874149	
Comprimento da linha	23	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

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Comprimento equivalente	89,98	m
Comprimento Equivalente total	112,98	m
Perda de carga na tubulação principal para este trecho	**3,15**	mca
Desnível geométrico da tubulação individual do poço	**4,00**	m
PR - Pressão residual	34,73	mca
Nível dinâmico do poço	33,00	m
Pressão no nó da conexão com o poço	**74,88**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	37,00	mca
Hr - Perda de carga no recalque	3,15	mca
PR - Pressão residual	34,73	mca
Hman Total	**75**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	150	m³/h
Pressão por bomba	75	mca

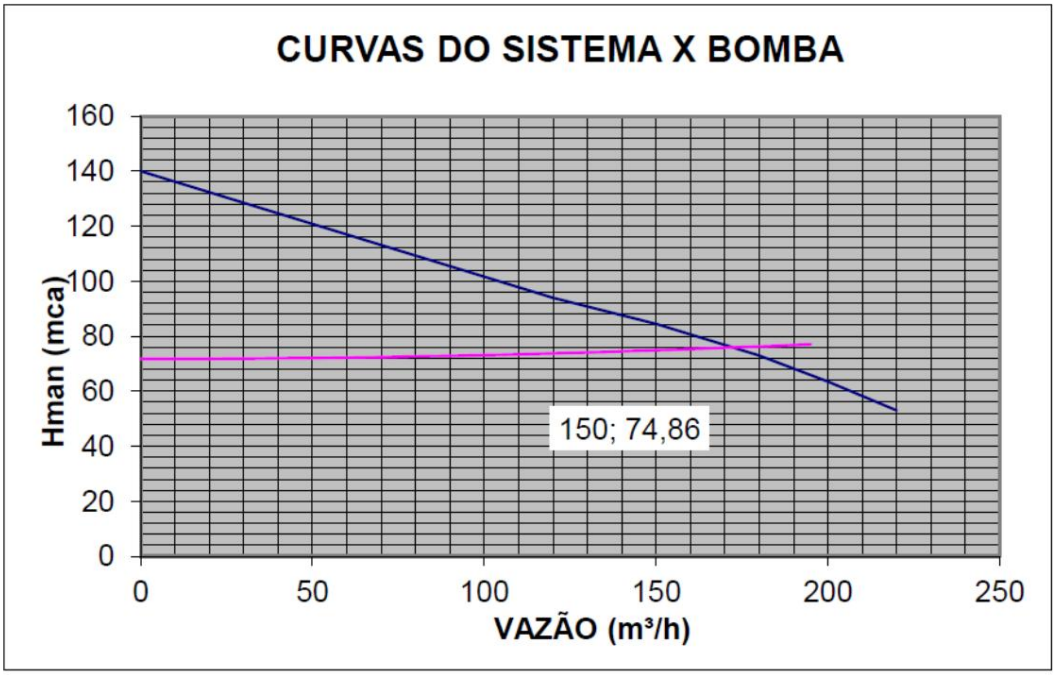
7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 804	
Rendimento	62	%
NPSH requerido	5,8	mca
Quantidade de estágios	4	

7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	66,98	cv
Rendimentos mecânicos:	88%	
Potência do motor:	75,83	cv
Motor adotado:	**100**	cv

8. Curvas do sistema

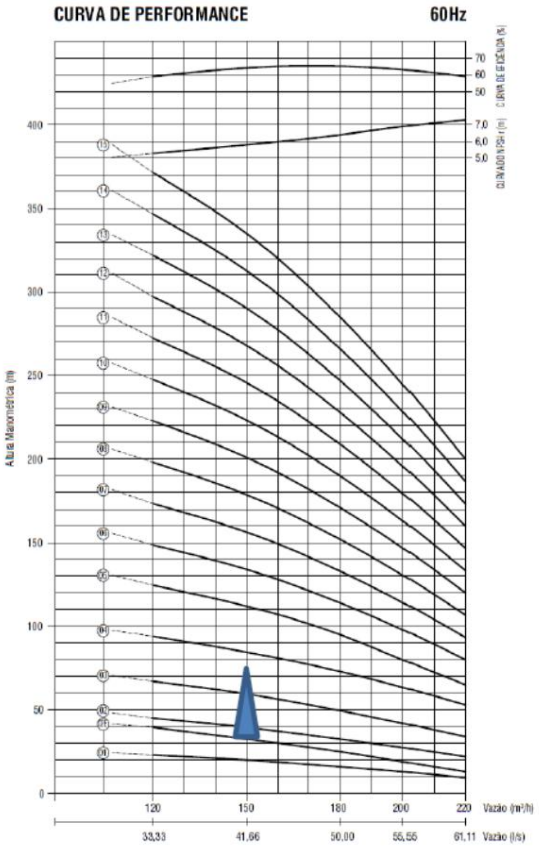


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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

9. Curva do fabricante



CÁLCULO DA PRESSÃO NA TUBULAÇÃO ATÉ O NÓ 5

1. Dados de entrada - Tubulação principal

Fluido	**Água bruta**	
Vazão	**305,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações - Tubulação principal

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,232	m
Diâmetro de recalque adotado	**0,3412**	m
Velocidades para ϕ adotados no recalque (m/s)	0,93	m/s

3. Tubulação selecionada - Tubulação principal

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga - Tubulação principal

Número de Reynolds	354215	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,013982921	
Comprimento da linha	1810	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	2	30	60
Curva 45	9	16	144

Comprimento equivalente	69,60	m
Comprimento Equivalente total	1879,60	m
Perda de carga na tubulação principal para este trecho	**3,37**	mca
Desnível geométrico desde a conexão até o próximo nó	**9,00**	m
PR - Pressão residual	34,73	mca
Pressão no nó da conexão com o próximo trecho	**47,10**	mca

Cálculos para o poço E1

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

1. Dados de entrada - Poço E1

Fluido	**Água bruta**	
Vazão	**90,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,126	m
Diâmetro de recalque adotado	**0,15408**	m
Velociddes para ϕ adotados no recalque (m/s)	1,34	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	231458	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,017666769	
Comprimento da linha	74	m

Perda de carga localizada

Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	163,98	m
Perda de carga na tubulação principal para este trecho	**1,72**	mca
Desnível geométrico da tubulação individual do poço	**4,00**	m
PR - Pressão residual	47,10	mca
Nível dinâmico do poço	50,00	m
Pressão no nó da conexão com o poço	**102,83**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	54,00	mca
Hr - Perda de carga no recalque	1,72	mca
PR - Pressão residual	47,10	mca
Hman Total	**103**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	90	m³/h
Pressão por bomba	103	mca

7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 813	
Rendimento	71	%
NPSH requerido	4,5	mca

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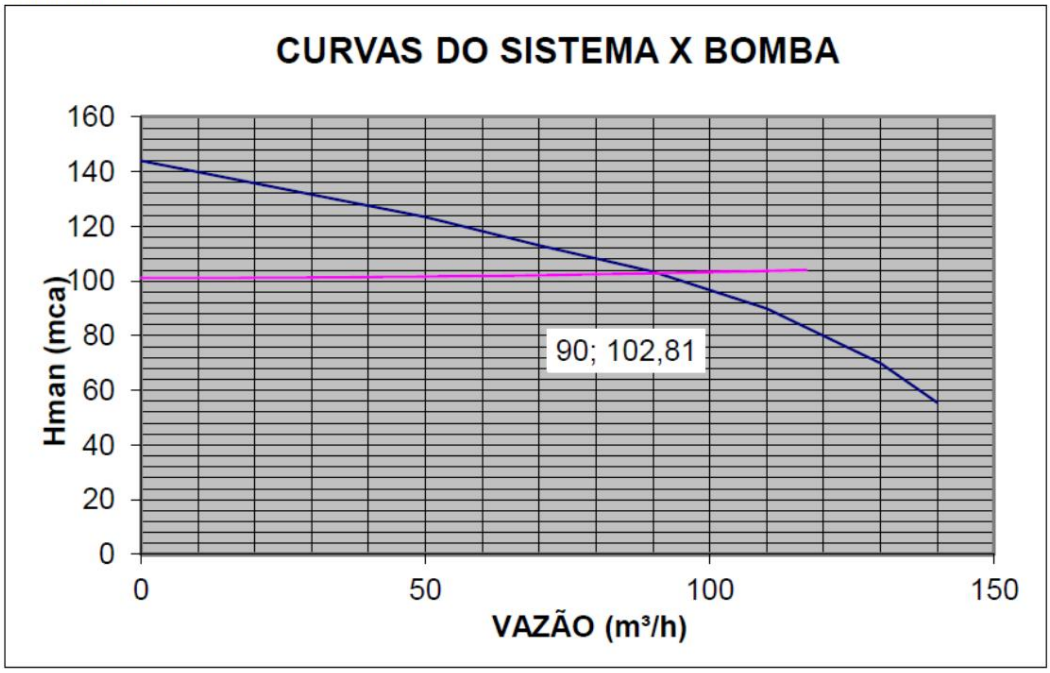
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Quantidade de estágios	4	

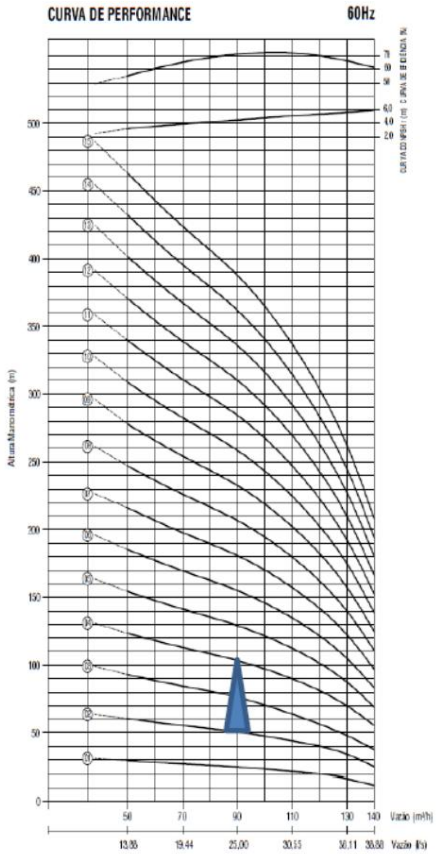
7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	48,19	cv
Rendimentos mecânicos:	88%	
Potência do motor:	54,56	cv
Motor adotado:	75	cv

8. Curvas do sistema



9. Curva do fabricante



CÁLCULO DA PRESSÃO NA TUBULAÇÃO ATÉ O NÓ 6

1. Dados de entrada - Tubulação principal

Fluido	Água bruta	
Vazão	215,0	m³/h

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RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações - Tubulação principal

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,195	m
Diâmetro de recalque adotado	**0,3412**	m
Velocidades para ϕ adotados no recalque (m/s)	0,65	m/s

3. Tubulação selecionada - Tubulação principal

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga - Tubulação principal

Número de Reynolds	249693	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,014921316	
Comprimento da linha	220	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	2	30	60
Curva 45	5	16	80

Comprimento equivalente	47,77	m
Comprimento Equivalente total	267,77	m
Perda de carga na tubulação principal para este trecho	**0,25**	mca
Desnível geométrico desde a conexão até o próximo nó	**0,00**	m
PR - Pressão residual	47,10	mca
Pressão no nó da conexão com o próximo trecho	**47,36**	mca

Cálculos para o poço F1

1. Dados de entrada - Poço F1

Fluido	**Água bruta**	
Vazão	**80,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,119	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	1,19	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	205741	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,017888297	
Comprimento da linha	159	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	248,98	m
Perda de carga na tubulação principal para este trecho	**2,09**	mca
Desnível geométrico da tubulação individual do poço	**13,00**	m

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PR - Pressão residual	47,36	mca
Nível dinâmico do poço	8,94	m
Pressão no nó da conexão com o poço	**71,39**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	21,94	mca
Hr - Perda de carga no recalque	2,09	mca
PR - Pressão residual	47,36	mca
Hman Total	**71**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	80	m³/h
Pressão por bomba	71	mca

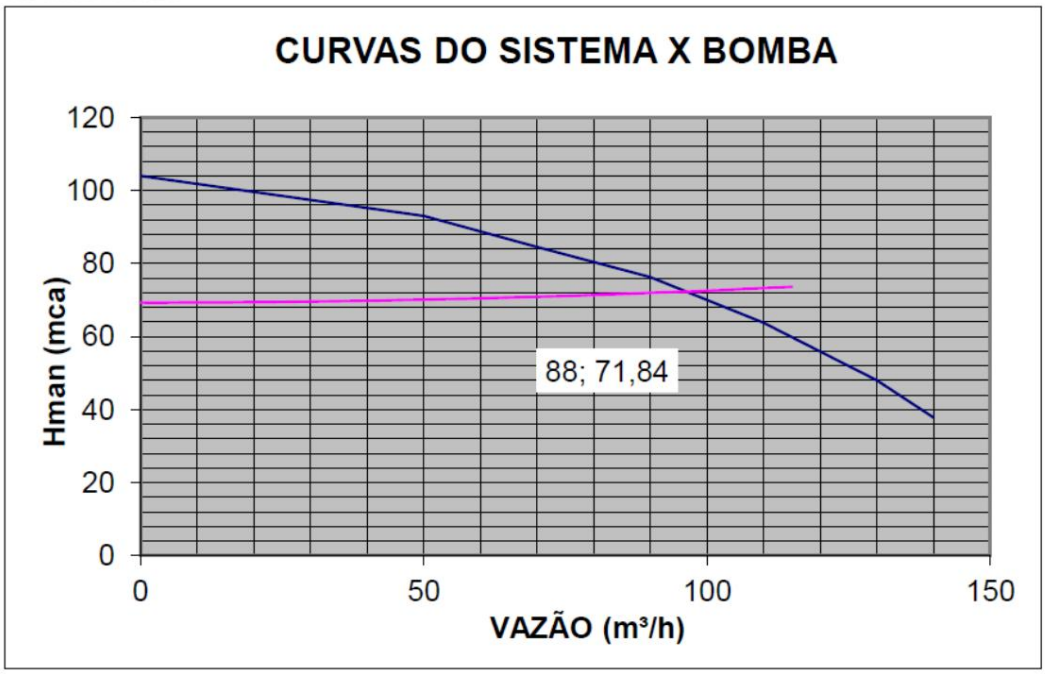
7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 813	
Rendimento	69	%
NPSH requerido	4	mca
Quantidade de estágios	3	

7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	30,60	cv
Rendimentos mecânicos:	88%	
Potência do motor:	34,65	cv
Motor adotado:	**50**	cv

8. Curvas do sistema

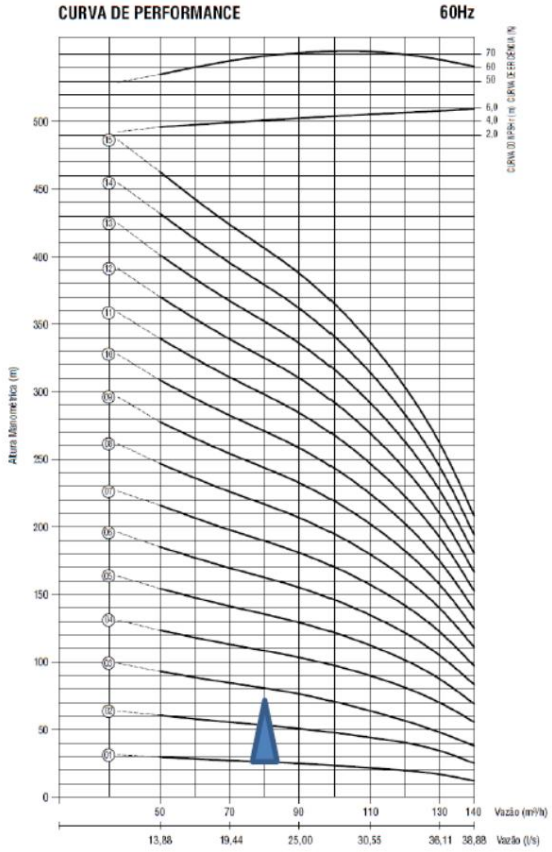


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Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

9. Curva do fabricante



CÁLCULO DA PRESSÃO NA TUBULAÇÃO ATÉ O NÓ 7

1. Dados de entrada - Tubulação principal

Fluido	**Água bruta**	
Vazão	**135,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações - Tubulação principal

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,155	m
Diâmetro de recalque adotado	**0,3412**	m
Velocidades para ϕ adotados no recalque (m/s)	0,41	m/s

3. Tubulação selecionada - Tubulação principal

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga - Tubulação principal

Número de Reynolds	156784	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,016329375	
Comprimento da linha	950	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	2	30	60
Curva 45	7	16	112

Comprimento equivalente	58,69	m
Comprimento Equivalente total	1008,69	m
Perda de carga na tubulação principal para este trecho	**0,41**	mca
Desnível geométrico desde a conexão até o próximo nó	**20,00**	m
PR - Pressão residual	47,36	mca
Pressão no nó da conexão com o próximo trecho	**67,77**	mca

Cálculos para o poço G1

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Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

1. Dados de entrada - Poço G1

Fluido	**Água bruta**	
Vazão	**85,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,123	m
Diâmetro de recalque adotado	**0,15408**	m
Velocidades para ϕ adotados no recalque (m/s)	1,27	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	218599	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,017772313	
Comprimento da linha	150	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	239,98	m
Perda de carga na tubulação principal para este trecho	**2,26**	mca
Desnível geométrico da tubulação individual do poço	**0,00**	m
PR - Pressão residual	67,77	mca
Nível dinâmico do poço	22,86	m
Pressão no nó da conexão com o poço	**92,90**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	22,86	mca
Hr - Perda de carga no recalque	2,26	mca
PR - Pressão residual	67,77	mca
Hman Total	**93**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	85	m³/h
Pressão por bomba	93	mca

7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 813	
Rendimento	70	%
NPSH requerido	4,5	mca

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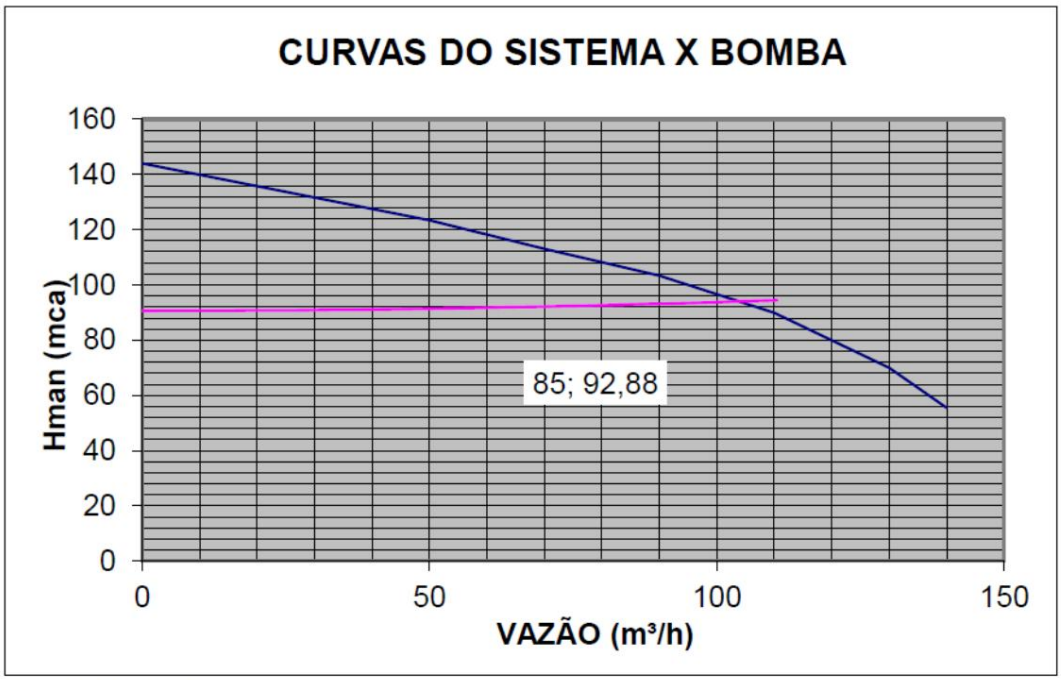
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Quantidade de estágios	4	

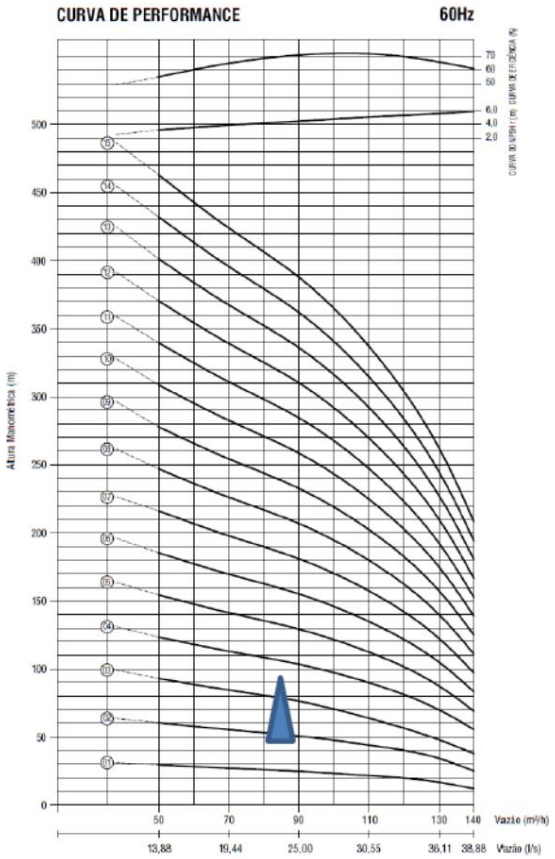
7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	41,70	cv
Rendimentos mecânicos:	88%	
Potência do motor:	47,22	cv
Motor adotado:	**50**	cv

8. Curvas do sistema



9. Curva do fabricante



CÁLCULO DA PRESSÃO NA TUBULAÇÃO ATÉ O NÓ 8

1. Dados de entrada - Tubulação principal

Fluido	**Água bruta**	
Vazão	**50,0**	m³/h

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ISSN: 2675-9128. São Paulo-SP.

Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações - Tubulação principal

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,094	m
Diâmetro de recalque adotado	**0,3412**	m
Velociddes para ϕ adotados no recalque (m/s)	0,15	m/s

3. Tubulação selecionada - Tubulação principal

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
400	**PN12,5**	**PE100**	**29,4mm**

4. Cálculo da perda de carga - Tubulação principal

Número de Reynolds	58068	
Coeficiente de Rugosidade	0,001	mm
Fator de Atrito (Churchill)	0,02010633	
Comprimento da linha	380	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	3	30	90
Curva 45	6	16	96

Comprimento equivalente	63,46	m
Comprimento Equivalente total	443,46	m
Perda de carga na tubulação principal para este trecho	**0,03**	mca
Desnível geométrico desde a conexão até o próximo nó	**3,00**	m
PR - Pressão residual	67,77	mca
Pressão no nó da conexão com o próximo trecho	**70,80**	mca

Cálculos para o poço H1

1. Dados de entrada - Poço H1

Fluido	**Água bruta**	
Vazão	**50,0**	m³/h
Temperatura	**25,0**	°C
Viscosidade	**8,93E-07**	m²/s
Peso específico	**0,998**	t/m³

2. Cálculo do diâmetro das tubulações

Velocidade econômica (m/s)	**2,00**	m/s
Diâmetro conforme velocidade econômica (m)	0,094	m
Diâmetro de recalque adotado	**0,15408**	m
Velociddes para ϕ adotados no recalque (m/s)	0,75	m/s

3. Tubulação selecionada

ϕ Tubo	Designação espessura	Material da tubulação	Espessura da parede
6"	**sch40/std**	**ASTM A53GrB**	**7,11mm**

4. Cálculo da perda de carga

Número de Reynolds	128588	
Coeficiente de Rugosidade	0,050	mm
Fator de Atrito (Churchill)	0,018939646	
Comprimento da linha	802	m

Perda de carga localizada			
Acessórios	Quantidade	L/D	Total
Curva 90	1	30	30
Curva 45	3	16	48
Valvula borboleta	2	8	16
Válvula globo	1	350	350
Valvula retencao	1	100	100
T direto	2	20	40

Comprimento equivalente	89,98	m
Comprimento Equivalente total	891,98	m
Perda de carga na tubulação principal para este trecho	**3,10**	mca
Desnível geométrico da tubulação individual do poço	**-15,00**	m

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PR - Pressão residual	70,80	mca
Nível dinâmico do poço	30,00	m
Pressão no nó da conexão com o poço	**88,91**	mca

Definição do equipamento empregado no poço

5. Altura manométrica total calculada para a bomba deste poço

Ho - Desnível geométrico	15,00	mca
Hr - Perda de carga no recalque	3,10	mca
PR - Pressão residual	70,80	mca
Hman Total	**89**	mca

6. Cálculo do NPSH disponível

Posição da bomba em relação ao nível da água:	AFOGADA	
Pa - Pressão atmosférica	9,49	mca
Pv - Pressão de vapor p/ temp. trabalho	0,75	mca
Hs - Altura mínima de afogamento	6,00	mca
hs - Perda de carga na linha de sucção	1,00	mca
NPSH disponível	13,74	mca

7. Seleção da bomba

7.1. Definição da associação das bombas

Associações em paralelo:	1,00	
Associações em série	1,00	
Vazão por bomba	50	m³/h
Pressão por bomba	89	mca

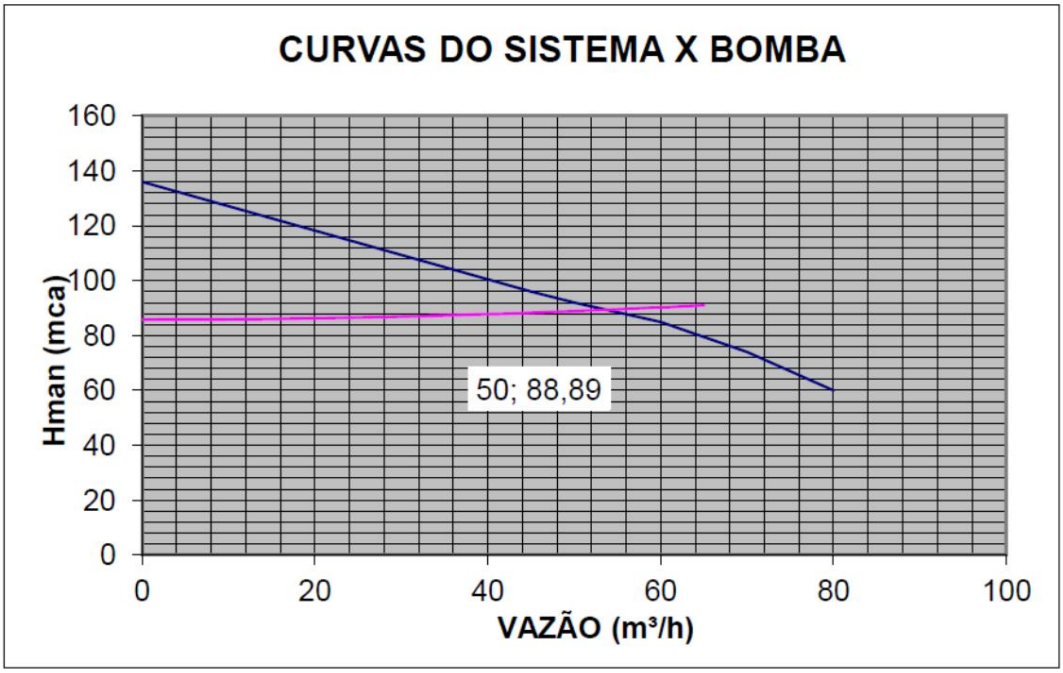
7.2. Bomba selecionada

Fornecedor	EBARA	
Modelo	BHS 517	
Rendimento	68	%
NPSH requerido	3,3	mca
Quantidade de estágios	8	

7.3. Cálculo da potência

BHP = (Q*Hman*Peso específico)/(75*rendimento)=	24,17	cv
Rendimentos mecânicos:	88%	
Potência do motor:	27,36	cv
Motor adotado:	**30**	cv

8. Curvas do sistema

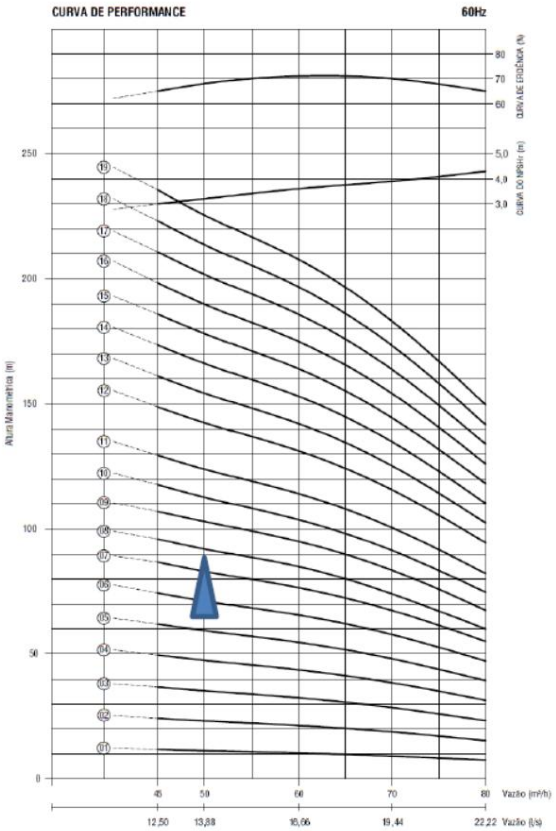


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Year IV, v.2 2023 | Submission: 05/09/2023 | Accepted: 09/09/2023 | Publication: 11/09/2023

9. Curva do fabricante



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