Quick Links Troubleshooting Do It Yourself Cable Selection Chart Pipe Loses Calculators Pumps Glossary Water Terms Engineering Info Knowledge Base Useful Conversions
Types of Pump Axial Flow Pumps Bladder Pumps Booster Pumps Cantilever Pumps Centrifugal Pumps Centrifugal Pumps 2 Chemical Pumps Condensate Pumps Cryogenic Pumps DC Powered Pumps Diaphragm Pumps Dosing Pumps Double Diaphragm Pumps Drum Pumps Explosion Proof Pumps Fluid Transfer Pumps Fountain Pumps Gear Pumps Grinder Pumps Hand Pumps Hydraulic Pumps Injection Pumps Jet Pumps Lift Stations Liquid Pump Lobe Pumps Magnetic Drive Pumps Mechanical Vaccum Pumps Metering Pumps Peristaltic Pumps Piston Pumps Plastic Pumps Positive Displacement Pumps Progressing Cavity Pumps Sump Pumps Syringe Pumps

When a fluid, be it hot or cold, has to be "moved" in a system, pumps are used. In other words, and in a technically more appropriate manner, the pump is a hydraulic working machine which has the function of increasing the total (mechanical) energy of a liquid; this means that the pump transfers to the fluid, which flows through it, to the extent allowed by its performance, part of the energy that it receives from the driving motor. At this point we can already make an important distinction based on the driving motor:

- we speak of an electropump when the mechanical energy necessary for the pump to turn is provided by an electric motor;
- we speak of a motor pump when this mechanical energy is provided by a heat engine (combustion engine, diesel engine, etc.).

Here we shall deal exclusively with electropumps - and further on we shall pause to describe the most important characteristics of the electric motors that drive them - because:

1. electric motors are the most widely used;
2. KIWI PUMPS produces and markets electropumps.

Considering the definition, we may proceed with our description of the pump, starting with the fundamental factors that describe its operation:

a. **Flow Rate:**
The flow rate of the pump is defined as the useful volume of liquid distributed by the pump in the time unit. It is generally indicated with the letter Q and is measured in m3/s, or in m3/h, or in l/min.

b. **Head:**
The (total) head of the pump represents the increase in energy acquired by 1 kg of liquid between the input and the output section of the pump itself; this is generally indicated with the letter H and is measured in J/kg or in metres of carried liquid (m. C.L.). It is much more convenient to speak not of the head but of the manometric head, indicated as H_{man} and measured in m C.W. (metres of column of water): saying that a certain pump gives a flow rate of 3 m^3/h with a manometric head of 12 m C.W. means that pump can lift a quantity of water amounting to 3 m^3/h up to a maximum height of 12 m. The applicable equation is: H_{man} [m C.A.] = H[m C.L.] * γ[kg/dm^3], where γ = volume of the

liquid transported. All pumps are provided with a data plate which clearly indicates, among the other data, the flow rate, manometric head and their interconnection. However these two parameters are not fixed, but vary inversely to one another: when one increases, the other decreases and vice versa. If the various points of operation of a pump are plotted on a graph, on which the X-axis represents the flow rate and the Y-axis the manometric head, the so-called characteristic curve $Q\text{-}H_{man}$ of the pump is obtained.

The characteristic curve may be "flat" or "steep", depending on how the pump has been designed and on the system in which the pump is to be fitted. As may be seen in figure 2, the pumps that have a flat characteristic curve give rise to slight variations in head for strong variations of flow rate, while pumps with a steep characteristic curve give rise to slight variations in flow rate for high variations in head. So pumps of the first type will be preferable when a more or less constant head is desired with a flow rate varying within ample margins (this is the case, for example, of pumps for fire-fighting installations); vice versa, pumps of the second type will be preferable when a more or less constant flow rate is desired with a head varying within a relatively wide field (for example in the case of pumping from wells, where constant flow rates are generally desired even in the presence of high variations in the geodetic difference in level).

c. **Power:**
There is the power supplied by the pump to the liquid, expressed as:
$P_u[W] = g[m/s2] * \gamma[kg/m^3] * Q[m3/s] * H[m\ C.L.]$, where $g[m/s^2]$ is the acceleration of gravity, generally equal to 9,81 m/s^2. Then there is the power P_{nom} absorbed by the pump, that is, in the case of electropumps, the power transferred by the electric motor to the pump axle. Then there is the electric power P_{abs} absorbed by the electric drive motor from the power mains.

d. **Efficiency:**
There is the efficiency η_p of the pump, defined as the ratio between the power P_u supplied to the fluid and the power P_{nom} aabsorbed by the pump (that is the mechanical power transferred by the electric motor): $\eta_p = P_u / P_{nom}$. Then there is the efficiency η_{mot} of the electric motor, defined as the ratio between the power absorbed by the pump and that absorbed by the motor: $\eta_{mot} = P_{nom} / P_{ass}$. In the case of electropumps we frequently speak of the efficiency of the unit, defined as the ratio between the power supplied to the fluid and the power absorbed by the motor:
$\eta_{gr} = P_u / P_{ass} = \eta_p * \eta_{mot}$. It must be stressed that the efficiency η_{gr} of the unit is a very important parameter for an electropumps: the higher its value the less the cost, in terms of electric energy and in money in the long run, that must be borne to have the electropump perform a certain job.

e. **Speed:**
The rotation speed is the number of revolutions performed by the pump in the time unit; this is generally indicated with the letter n and measured in rpm. All KIWI PUMPS electropumps are fitted with a 2-pole induction motor; considering the average running of the motors and the fact that the electric energy distributed in the mains generally has a frequency of 50 or 60 Hz, this gives roughly
n(50 Hz) = 2750 - 2950 rpm and n(60 Hz) = 3300 - 3550 rpm.

f. **NPSH:**

This parameter indicates the pump's inability to create an absolute vacuum, that is the inability of all centrifugal pumps to suck at a height equal to or higher than 10.33 m (which generally corresponds to the value of atmospheric pressure at sea level). From the physical point of view, the NPSH indicates the absolute pressure that must exist at the pump intake to prevent the occurrence of cavitation phenomena. When a pump tries to suck up a certain amount of liquid from a depth greater than that allowed by its characteristics, cavitation occurs: the impeller interrupts the flow of liquid and, as a result, small vapour bubbles are formed; these bubbles implode shortly after being formed, making a loud noise similar to metallic hammer and causing severe damage to the hydraulic parts of the pump. That is why it is important for every pump manufacturer to indicate clearly, among the characteristics of his machines, the maximum suction depth, or to supply the curve of the NPSH as a function of flow rate. The maximum suction depth H_{max} and NPSH are linked by the relationship:

$H_{max} = A - NPSH - H_{asp} - Hr$ (m)

dwhere: A = absolute pressure in m on the free surface of the fluid in the suction tank; if fluid is being sucked from an "open" tank, that is in contact with the atmosphere, A is equal to the atmospheric pressure;

H_{asp} = load loss in the suction pipe in m;
H_r = vapour tension of the liquid transported in m.

The NPSH is influenced by the flow rate value: it grows as the latter increases; as a result, in order to return the pump to regular operation it is often sufficient to choke the delivery gate valve suitably, thus reducing the flow rate of the pump.

As may be seen from the equation above, to increase the maximum suction depth of a certain pump the load losses H_{suc} of the suction pipe may be decreased: that is why it is always convenient to fit a pipe with the largest possible internal diameter at suction.

Characteristic Curve of the System - Working Point
In a (hydraulic) pumping system, the following may be distinguished:

- the suction channel or tank, that is the "environment" from which the pump takes the liquid;
- the suction duct or pipe through which the liquid is led to the pump (missing only in systems where the pump body is immersed);
- the delivery duct or pipe into which the pump sends the liquid;
- the delivery channel or tank, that is the "environment" into which the pump sends the liquid that it has lifted.

The energy required to carry 1 kg of liquid from the suction tank to the delivery tank is:

$H_i = (H_m - H_a) + H_g + H_p$ (m)

where:

H_m e H_a, expressed in C.L., are the pressures on the free surface of the liquid in the delivery tank and in the suction tank respectively. If both tanks are at atmospheric pressure, the term ($H_m - H_a$) is equal to zero;
H_g is the geodetic difference in level, in metres, of the system: the examples given in figure 3 show how it should be measured;
H_p is the total load losses, in metres, of the suction pipe (if fitted) and of the delivery pipe. Load losses are the energy losses that take place during movement of the liquid; they may be "continuous" or "accidental". The former are those due to friction between the fluid and the pipe whereas accidental losses are due to a variation in speed (widening or narrowing of the section, mouths and outlets, valves, etc.) and to changes in direction (curves, elbows, etc.). To calculate load losses, graphs and/or tables are generally used that may be easily found in good books on hydraulics or on pumping systems.

While H_m, H_a, H_g generally remain constant as the flow rate varies, the load losses Hp increase as the flow rate increases following a fairly quadratic law: as a result the value of Hi also increases as the flow rate increases.

If a graph is drawn showing the values of Hi as a function of flow rate, the so-called "line of total resistance or characteristic curve of the system" is obtained. Generally the characteristic curve of the system is plotted by joining a certain number of coordinate points (Q, H_i), bearing in mind that, as we have said, only the term H_p varies as Q varies.

From this brief description it may already be deduced that the working point does not depend only on the pump's characteristics, but is also a function of the type of system in which the pump is fitted: it is sufficient to manoeuvre a gate valve fitted on the pump delivery, thus varying the load losses there, or to vary the level of the liquid in the suction or delivery tank, thus varying the geodetic difference in level Hg, to shift the working point to a different capacity.

Special pipes and pieces

Dimensions and Arrangements of Special Pipes and Pieces

1. The rated diameters of the pump mouths do not give any reference for establishing the diameters of the suction and delivery pipes.

   For delivery pipes of limited length, the flow rate and capacity may be fixed according to the following table (approximate values supplied as a guide):

internal diameter (mm):	25	32	40	50	65	80	100	150	200
flow rate (m/s)	1,4	1,4	1,5	1,6	1,7	1,8	1,9	2,0	2,1
capacity (m3/h):	2,5	4,1	7	11	20	33	54	127	237

2.

For delivery pipes of considerable length (therefore for high power pumping systems), the diameter is chosen according both technical and economic criteria.

It is advisable for the delivery pipe to be provided with a check valve and with a regulating valve. The former, which should be upstream from the latter so that it may be inspected and replaced if necessary without emptying the delivery pipe, must protect the pump against water hammer and prevent inverse flow though the impeller in the event of sudden stopping of the unit. The regulating valve, on the other hand, is used to vary the power raised by the machine and therefore to satisfy the requirements of the user.

3. The suction pipe requires greater attention than the delivery pipe, as a mistake in its installation or in choosing its dimensions may cause serious problems (the major one being cavitation, with all the problems that accompany it). To guarantee the best and most efficient suction conditions, this pipe must be as short as possible, vertical or rising towards the pump (so as to avoid air pockets which could cause the pump to become unprimed), without choking or sudden changes in direction. Save in the exceptional case of complex systems, along the suction pipe there must not be valves of any kind except the foot valve fitted at the immersed end of the suction pipe; in the case of Jet self-priming pumps, the foot valve may be replaced by a check valve fitted directly on the suction mouth.

   It must also be remembered that, in order to guarantee suction of the liquid to be pumped, this pipe must be hermetically closed, especially if there is a high geodetic difference in level at suction. At the same time there must be no high points where the air and/or gases dissolved in liquid can gather, thus causing an interruption in the flow; it is therefore best to fit flanged or threaded couplings, discarding solutions that consider cup or bell couplings which frequently cause an imperfect seal.

   To avoid the formation of vortices, and the consequent intake of air with the liquid to be pumped, the input section of the suction pipe must be about 0.4 - 1 m below the free suction surface, depending on the dimensions of the system.

   For short suction pipes the flow rate and capacity values indicated above may be chosen, multiplied by 0.8; however, the internal diameter must never be smaller than the diameter of the pump suction mouth.

4. Each pump should, if possible, have its own suction pipe so that it may be easily excluded from the system if the need arises, and also to prevent the entry of air in the suction manifold when the pump is stopped. If a single suction pipe has to be designed for several pipes, the delivery check valves must be eliminated and fitted on the suction mouths instead.

5. Special pieces (such as curves, elbows, derivations and connections, etc.) and various valves should be used only if built suitably: for further information on this subject, consult a good book on hydraulics or on pumping systems. In all cases remember that:
   a. the connections must be accurate so to avoid air re-entry and to prevent the gaskets from reducing the working section of the pipe passage, increasing its resistance;
   b. to choke the capacity, regulate only the gate valves fitted on the delivery pipe and never those on suction.

The Pumps » Electric Motors
Electropumps are generally fitted with 2 or 4-pole induction electric motors. Each KIWI PUMPS electropump is driven by an induction motor with a short-circuited rotor (squirrel cage), enclosed and self-ventilated, suitable for continuous duty, with 2 poles. The special characteristics of these motors are their simplicity and safety of operation, while they are particularly sturdy and inexpensive to run. They may be of the three-phase type or, for limited power ranges (roughly less than 3 Hp), even single-phase; the latter are generally produced with a permanently in-circuit capacitor.

The characteristics of an electric motor are:

a. **Rated Power and Rated Current:**
   The rated power of an electric motor is the mechanical power available to the shaft; it is expressed in Watt (W), in horse power (1 Hp = 745.7 W) or in metric horse power (1 CV = 736 W): for the sake of convenience it is frequently presumed that 1 CV = 1 Hp = 750 W.

   The rated current is the current absorbed by the motor, fed at rated voltage and frequency, when it supplies the rated power. The rated power differs from the absorbed power depending on the performance of the motor. It must be remembered that the rated power, or current, characterizes a well defined point of operation of the motor: the rated operation point. The actual power, or current, absorbed by the electric motor that drives an electropump depends on the point of work of the electropump: in centrifugal pumps, for example, the higher the flow rate, the greater the absorbed power.

   Due to problems of overheating, and frequently to avoid cavitation, it is of fundamental importance to use any electropump within the limits recommended by its manufacturer: only in this way can we be sure of not endangering the efficient functionality and long life of the machine.

b. **Rated Voltage and Frequency:**
   The rated voltage is the line voltage, or voltage between two phases, on the motor terminals at rated power. Its value is considered by the designer when planning the dimensions of the machine: for correct motor function, and therefore for that of the electropump, the mains voltage must not differ much from this value: on this subject, international regulations require that motor-driven appliances be able to supply their rated power, and therefore to function correctly, when they are fed at a voltage that may vary

by ±5% (6%) of the rated value.

If in a given country the mains voltage has a wide field of variation around a rated value, it is advisable to point this out to the manufacturer who may consider the possibility of designing a motor specially to deal with these characteristics.

Other important data which must always be indicated on the machine plate are the rated frequency - generally 50 Hz or 60 Hz - and the number of phases; generally single-phase or three-phase induction motors are used. As specified above, single-phase induction motors are almost always of the type with permanently in-circuit capacitor: in this case the data plate will show the capacity of the capacitor and the maximum voltage that it can withstand.

c. **Power Factor:**
The power factor (p.f.) or cos φ, generally not known or not considered by "non-technicians", indicates the phase difference between the vectors representing voltage, on the motor terminals, and the vectors representing the current that it absorbs. This is a very important parameter for an induction motor as, together with the performance, it indicates the quality of the motor: its value is all the higher when the designer establishes "good" dimensions without speculating too much on cost (using good quality laminations, allowing for ample dimensions of the pack and the number of leads in the winding, etc.).

It must also be remembered that, in the various countries, the electric energy distribution company requires that users have a minimum value of power factor: for values below this limit the user has to pay an excess charge for the energy consumed. The distribution company also has the power to enforce the user to alter his systems so as to bring the p.f. to a value that is not below the set limit: the lower the p.f. of a system, the higher the cost that must be incurred to bring it up to the minimum set value (or, to use the technical term, to correct the power factor of the system).

d. **Type of Duty:**
By duty of any electric machine is meant (the definition of) the load to which the machine is subjected, including (if applicable) the time intervals devoted to starting, electric braking, idling and pause time, their duration and sequence in time.

Without pausing to describe the various types of duty defined by the standards (continuous, limited duration, intermittent, etc.), we shall simply stress that each KIWI PUMPS electropump is driven by an induction motor, which may be single-phase or three-phase depending on the model, of enclosed and self-ventilated type, suitable for continuous duty, that is able to supply the performance declared on the data plate without interruption.

e. **Degree of Protection:**
Like other electric machines, electric motors too - and therefore electropumps - are classified according to the closing system, that is the protection against the entry of solid and liquid bodies.

The degree of protection of the casings of rotating electric machines is defined by the Standard with the initials IP (International Protection) plus two figures which may (at the manufacturer's discretion) be followed by one or two letters.

- The first characteristic figure serves as dual indication:
    a. protection of persons against access to dangerous parts, that is electrically active parts or moving mechanical parts;
    b. protection of the machine against the penetration of solid foreign bodies.

  In progression, the figures indicate gradually higher degrees of protection. It is also understood that a machine with, for example, degree 4 also complies with the lower degrees of protection (from 0 to 3).

- The second characteristic figure indicates protection against the harmful penetration of water.
- The purpose of the additional letter is to designate the level of inaccessibility of the machine casing to fingers or hands, or objects held by a person; this letter also denotes a strictly accident-prevention function and must be used only if the protection against access is higher than that defined with the first characteristic number.
- The purpose of the supplementary letter is to indicate particular conditions concerning the type of machine or its use.

All KIWI PUMPS electropumps are characterized by degree of protection IP44, that is they are protected against the access, to dangerous parts, of a wire or of solid bodies with dimensions higher than or equal to 1 mm (1st number), and against splashes of water coming from any direction (2nd number).