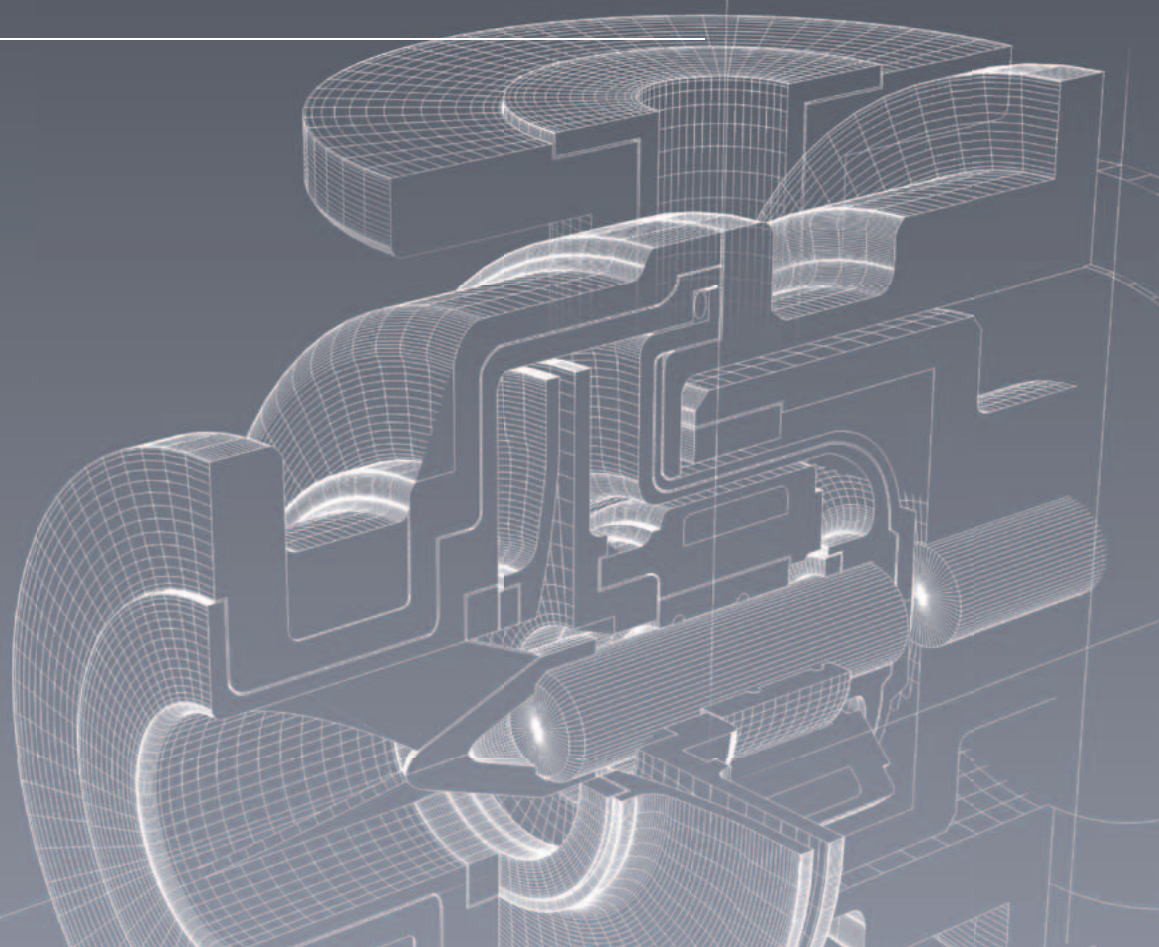




Process Magnetic Drive Pump

Global Technical Information



Introduction

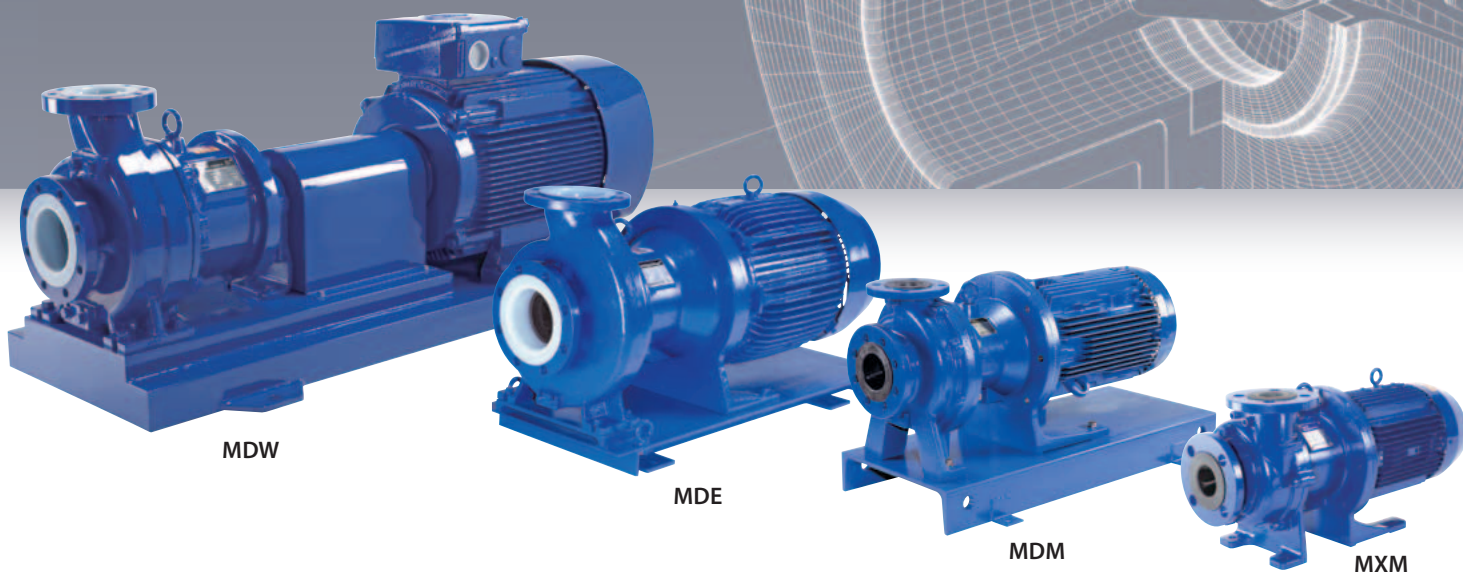
Magnetic drive pumps have become the norm in the corrosive-resistant pump marketplace.

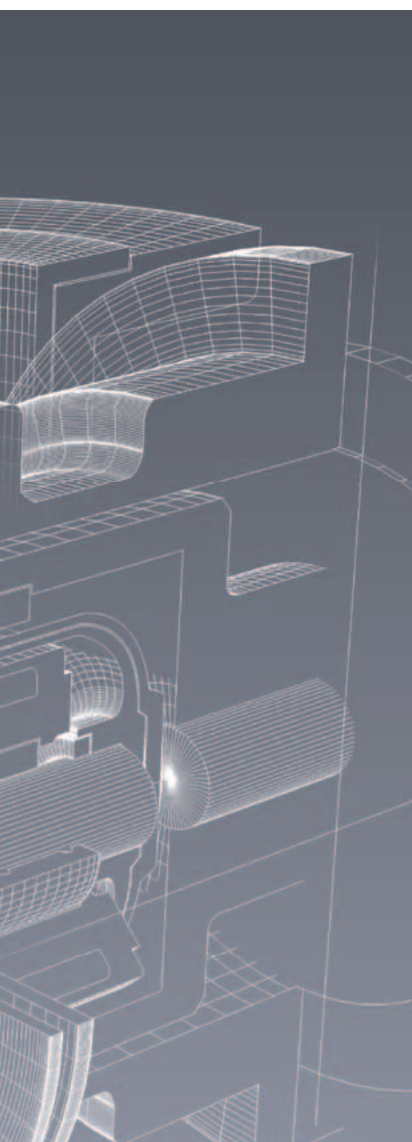
Iwaki's magnetic drive pumps are always on step ahead with a strong product lineup and superior performance.

These guidelines contain information and instructions on how to use Iwaki's larger magnetic drive pumps that are specially designed for heavy-duty applications.

Iwaki also offers many other types of products.

Please contact us separately for details on smaller magnetic drive pumps.





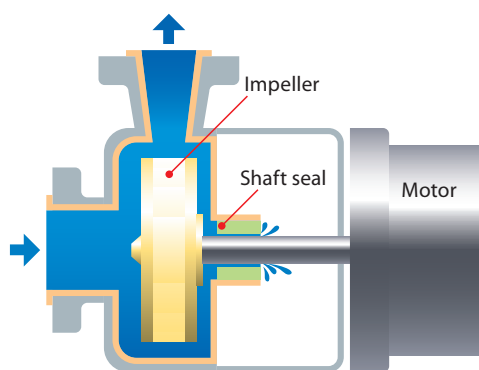
AMP

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Operating principles of a magnetic drive pump

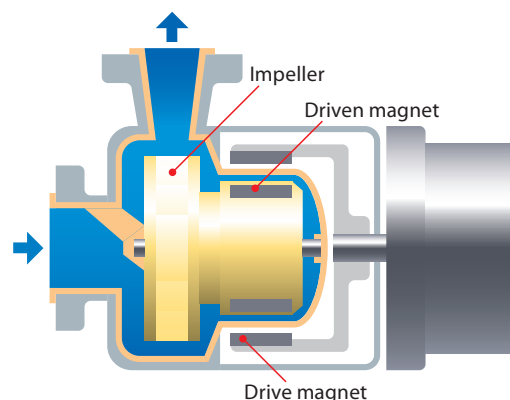
Pumps can be categorized into several types according to their structure and operating principle. Centrifugal pumps move fluids in the pump chamber (casing) using centrifugal force generated by a rotating impeller.

Typical centrifugal pumps have a pump shaft passing through the casing to transmit the motor power to an impeller in the casing. To keep liquid from leaking, the opening where the shaft enters the casing has a shaft seal, such as a mechanical seal or gland packing. However, with time, there may be minor leaks, or worn-out components may cause leaks.



Magnetic drive pumps are magnetically driven centrifugal pumps without shaft seals. An impeller incorporating a permanent magnet is rotated and driven by the magnet mounted on motor shaft.

The pump chamber is completely isolated, and the magnetic force from the drive magnet causes the magnet on the impeller to rotate. Since there is no pump shaft passing through the casing, no shaft seal such as a mechanical seal or gland packing is required. This eliminates the potential for leakage from the shaft seal.



The magnetic force transmitted between the drive magnet mounted on the motor shaft and the driven magnet built into the impeller (transmission torque) is designed to have a safety factor sufficient to accommodate the motor torque. Because the rotational speed of the motor perfectly synchronizes with the pump impeller speed, no power loss due to misalignment of the magnets (slippage) occurs.

What is a magnetic drive pump?

Construction and Components

Magnetic drive pumps employ a spindle within the pump housing which supports the rotating parts (impeller and magnet capsule).

The structure of magnetic drive pumps can be divided into two groups: rotating-spindle type and fixed-spindle type (where the spindle is fixed to the pump casing).

IWAKI has a lineup of both types of pumps that can be selected to match your application.

Rotating-Spindle Type

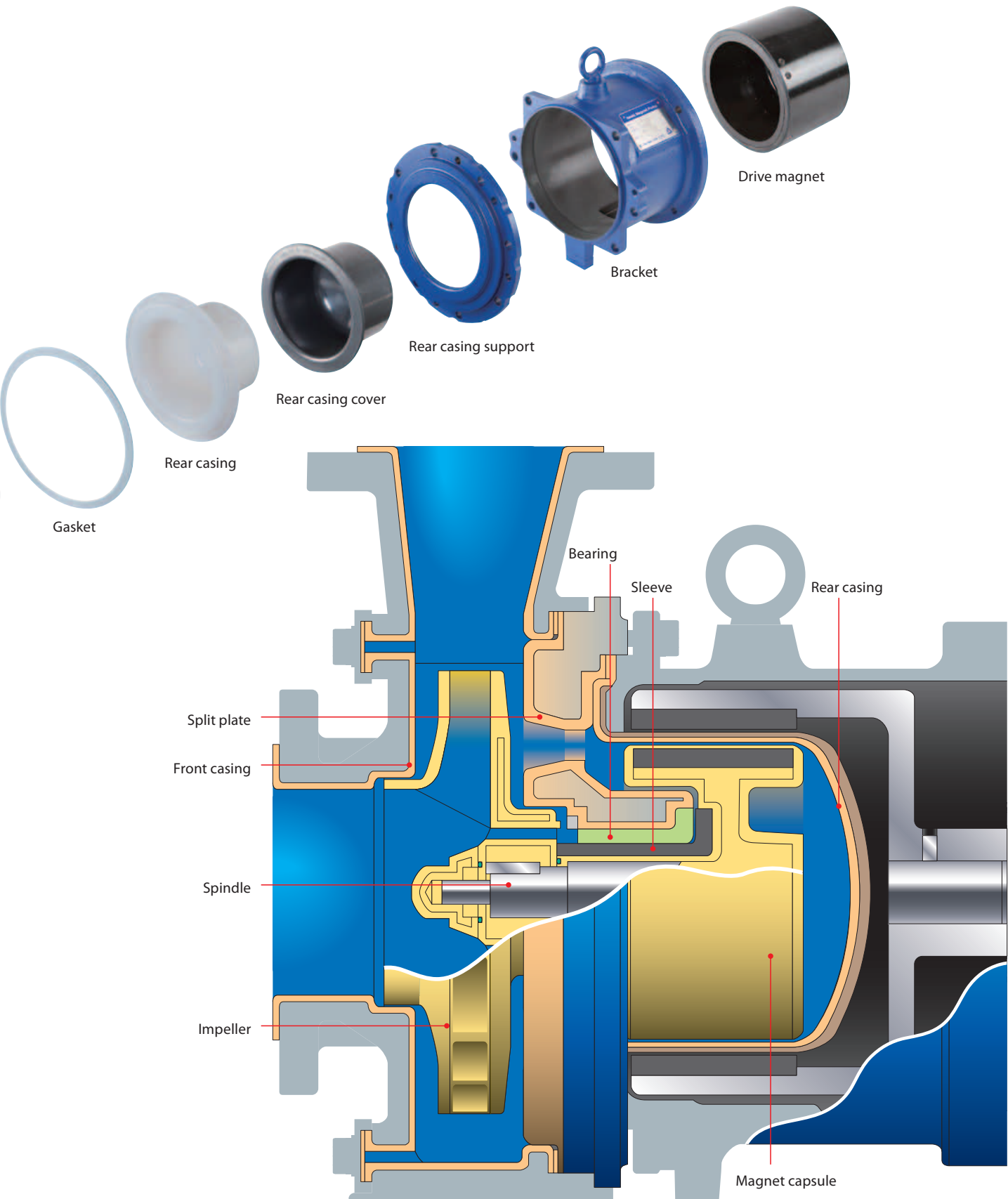
MDW

MDE

These pumps have a metal-reinforced split plate that supports the rotating parts within the pump housing, giving them the advantage of increased structural strength.

IWAKI MDW and MDE magnetic drive pumps employ this structure.





Fixed-Spindle Type

MDM

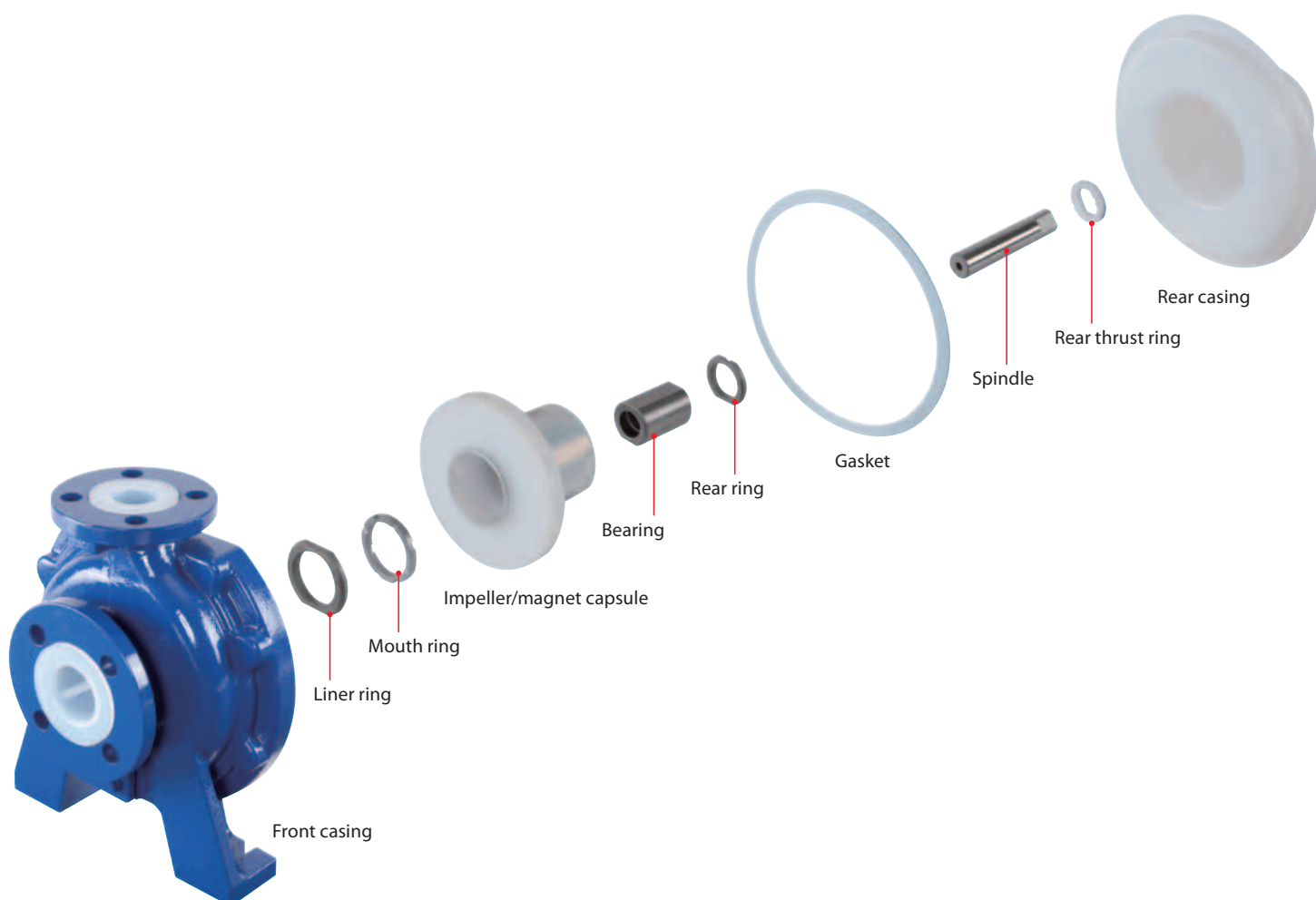
MXM

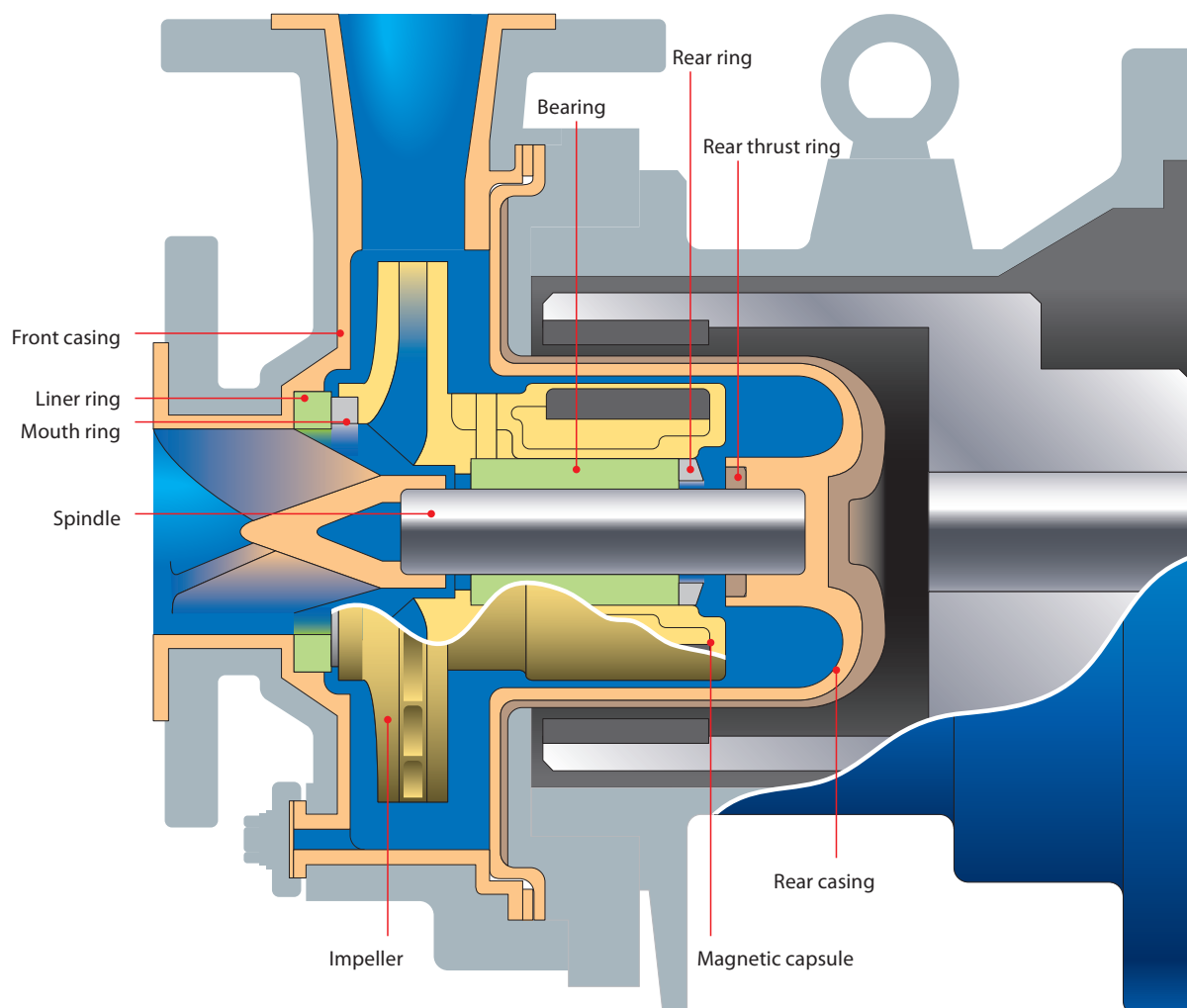
AMP

In a fixed-spindle type, both ends of the spindle are supported by the front and rear casing.

Their simple structure and compact design provide for ease of maintenance and make them more resistant to abnormal operation.

IWAKI MDM, MXM, and AMP magnetic drive pumps employ this structure.





Features of magnetic drive pumps

General Features

Magnetic drive pumps do not require a shaft seal and employ materials in their construction that have excellent corrosion resistance, providing them with the following features.

Leak-free Seal-less Structure
Can safely handle hazardous fluids

Simple Structure
Easy to maintain and overhaul

Excellent Corrosion Resistance
Can be used with a wide range of chemicals, including acids and alkalis

Wide Fluid Temperature Range

Glass fiber, carbon fiber, and other materials are added to create reinforced plastics.

This technique significantly improves the tensile strength, bending elasticity modulus, and compressive stress of those materials.

In addition, each part is reinforced using metal to improve thermal resistance and increase durability.

Drive (Power) Unit

As described in "Principles of Magnetic Pumps," the magnetic force between drive and driven magnets must be stronger than motor torque.

In a typical sealed centrifugal pump, the motor power required increases with the specific gravity of the fluid.

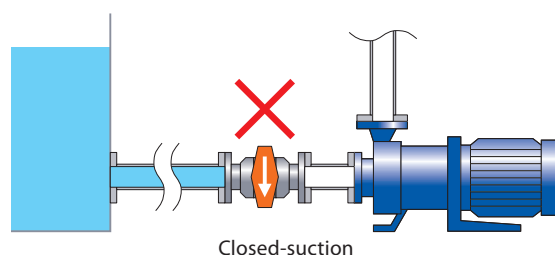
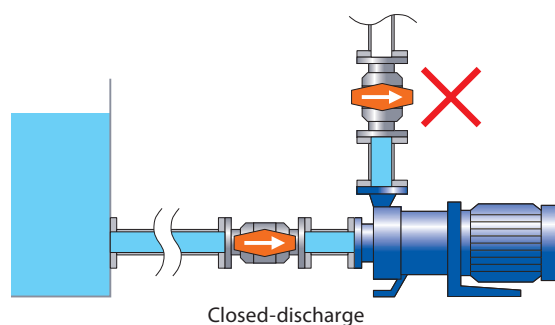
In a magnetic pump, both the magnetic strength of the magnets and the motor power must increase.

Dead Head Running

If a pump is running with the discharge-side valve closed, friction heat will build up on the sliding parts within the pump and captive liquid.

If the suction-side valve is closed, cavitation occurs almost immediately, which is not possible in any kind of pump, not just magnetic pumps.

Accordingly, the suction-side valve should always be fully open, and the discharge-side valve should be open as required to maintain a minimum flow rate.



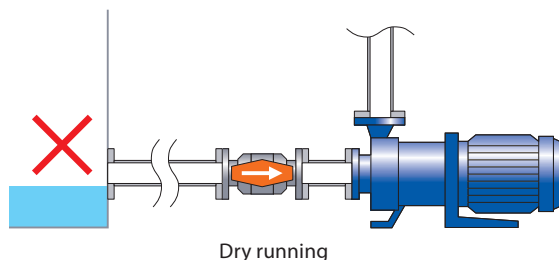
Dry Running

Dry running of all centrifugal pumps, not just magnetic pumps, will cause damage to the pump and is not recommended.

Bearings made from ceramic materials have excellent thermal resistance and corrosion resistance, but friction heat will impact the surrounding parts. In addition, ceramics may crack due to rapid changes in temperature (thermal shock).

If bearings are made from carbon-based material, part seizure is less likely to occur due to their self-lubrication, but dry running will hasten wear of the bearing.

If bearings are made from fluorocarbon polymers, the bearing can be deformed and scorched due to heat generated by the bearing itself.



Periodic inspection of wear components in accordance with the instruction manual and appropriate replacement of these components is required.

Slurry

In general, magnetic drive pumps are not suited for handling fluids containing slurry, although there is some variation in capability depending on the type of bearing material.

If the bearing material is carbon-based or a fluorocarbon polymer, the handling of slurry is not allowed.

If the bearing material is ceramic-based, the material has limited durability to friction with slurry. However, restrictions on handling slurry still apply for other wet end parts made from plastics (impeller, casing, etc.).

The nature of slurry can vary, so regular testing to determine whether slurry can be handled is recommended.

Component Life

Magnetic drive pumps use sliding components such as bearings, sleeves or spindles, and mouth rings in a structure that requires liquid lubrication.

The working life of these components is affected by various operating conditions, such as the nature of the fluid being pumped and the presence of slurry.

In IWAKI magnetic drive pumps, the dimensions and clearances (gaps) are designed based on our standard, with wear limits stipulated for maintaining performance.

Internal Circulation

Magnetic drive pumps employ a structure which supports the rotating parts (impeller/magnet capsule unit) within the pump housing using bearings.

Because moving parts use slide bearings designed for fluid circulation, a portion of the fluid being pumped circulates within the pump. The flow of fluid inside the pump is called the internal circulation.

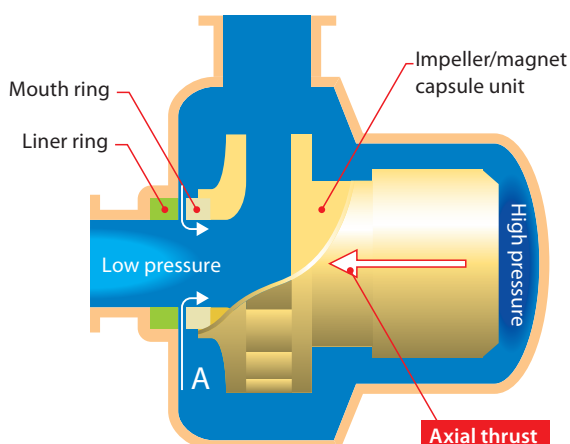
This section describes the internal circulation using a fixed-spindle type pump as an example.

Circulation around mouth ring

Low-pressure fluid entering from the suction inlet is pressurized by the rotation of the impeller. The pressure within the casing increases with the distance from the center, especially, at the bottom of rear casing.

Hence, a pressure differential occurs between the front and rear of the impeller/magnet capsule, giving rise to axial thrust force from the rear casing toward the suction inlet. The mouth ring and liner ring are displaced by this axial thrust force.

The mouth ring has a gap that supplies fluid for cooling to the sliding surfaces, flowing in response to the pressure differential between the front casing and the suction inlet, and this fluid then flows back toward the impeller. (A in the diagram).



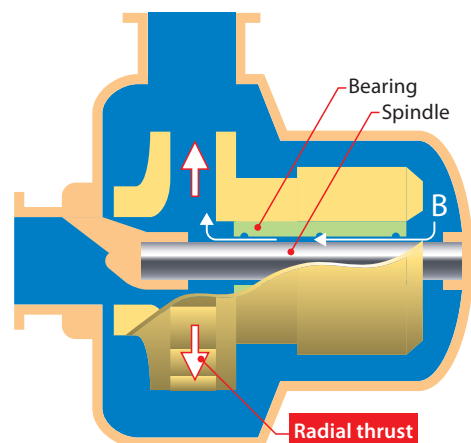
Circulation around bearings

The impeller/magnet capsule is also subjected to radial thrust force in addition to axial thrust force.

The radial thrust occurs due to imbalance in pressure within the casing.

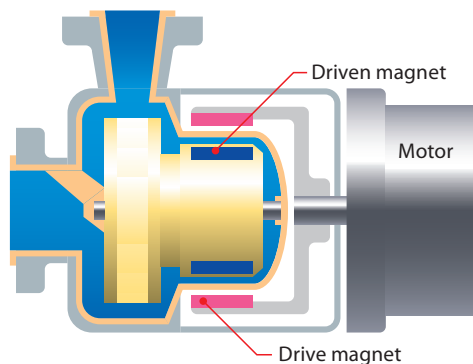
In general, at flow rates lower than the design specification, the pressure is higher in the vicinity of the discharge outlet, which pushes the impeller away from the outlet. At flow rates higher than the design specification, the pressure is lower in the vicinity of the discharge outlet, which pushes the impeller toward the discharge outlet. A load is applied to the bearing and spindle, as they slide, in response to this radial force and the weight of the impeller/magnet capsule.

The bearing has a gap that supplies fluid for cooling to the sliding surfaces, flowing in response to the pressure differential between the rear casing and the impeller inlet. This fluid then flows back toward the impeller. (B in the diagram).



Magnetic Coupling

A magnetic coupling is a mechanism for transferring power using magnetic force. The diagram below shows a cross-section of a magnetic pump.



The magnet unit connected to the motor shaft is called the drive magnet, and the magnet unit connected to the impeller is called the driven magnet.

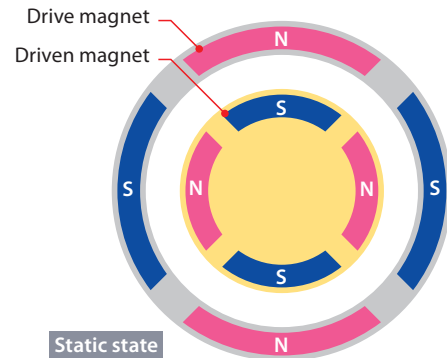
The drive magnet and driven magnet rotate synchronously. For example, if the motor rotates at 3000 rpm, the impeller also rotates at 3000 rpm.

The rear casing sandwiched between the two magnet units is made from plastics (non-magnetic) so that eddy current loss due to magnetic field induction in the casing cannot occur. As a result, there is no generation of heat due to eddy current and no loss of energy.

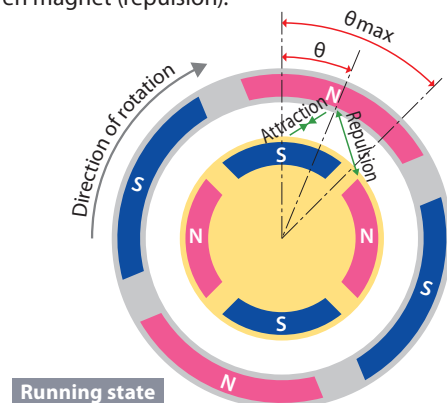
The following information describes how the magnetic coupling transmits torque (rotational power).

The first diagram shows a cross-section of the magnetic coupling.

The drive magnet and driven magnet both have alternating North (N) and South (S) poles arranged at equal intervals. N and S poles are attracted toward each other. This diagram shows the relative positions of the poles when in a state of rest. This position generates no torque, and is referred to as the neutral position.



In the second diagram, when the motor is running, the drive magnet leads the driven magnet in the direction of rotation by an angle θ . In this state, the N pole of the drive magnet pulls the S pole of the driven magnet (attraction) and simultaneously pushes the N pole of the driven magnet (repulsion).



Thus, the drive magnet is applying torque to the driven magnet. There is a correlation between the angle θ and the torque generated. The maximum torque is generated when the N pole of the drive magnet is about halfway between the S and N poles of the driven magnet ($\theta_{\max}$).

The strength of the magnetic coupling is designed to always be higher than the rated power of the motor by a safety margin. This provides additional torque for acceleration when starting the motor. As a result, the drive magnet angle θ should never exceed $\theta_{\max}$. However, if the applied load exceeds the design load, the two magnet units will slip poles (decoupling), losing synchronism and rendering the pump unable to pump fluid.

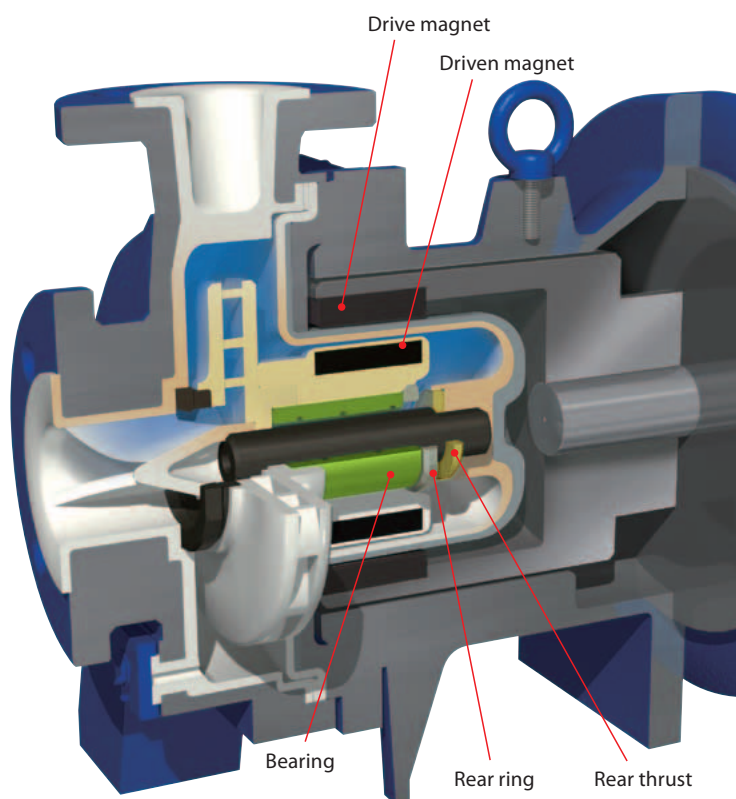
Distinguishing features of IWAKI's magnetic drive pumps

Non contact system (Pat.Pend.)

MDM

MXM

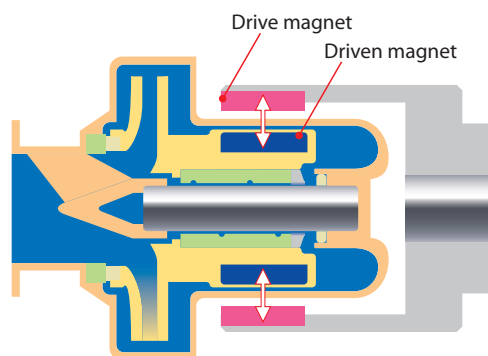
AMP



Unique Design Withstand Dry Running.

The pump design features a mechanism to withstand dry running. High magnetic power of the rare earth magnets prevents the magnet capsule from coming into contact with the thrust ring of the rear casing, thus preventing melting of fluororesin components due to heat generation. This greatly improves resistance to dry running in comparison with conventional magnetic drive pumps made of fluororesin.

Note: Only CF type (fitted with high density carbon bearing) can be run dry. Dry running is not possible in the case of KK type.



Back pull-out system

MDW

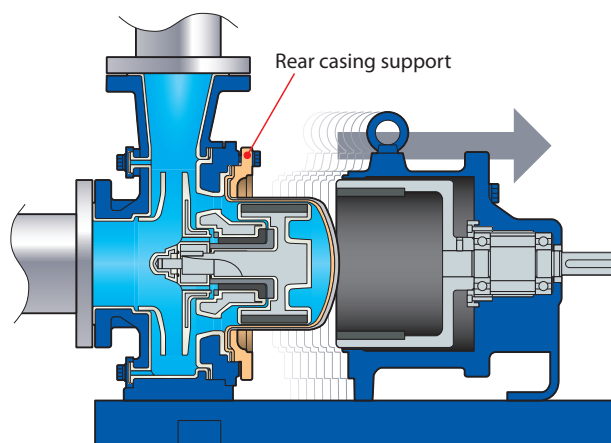
MDE

MDM

AMP

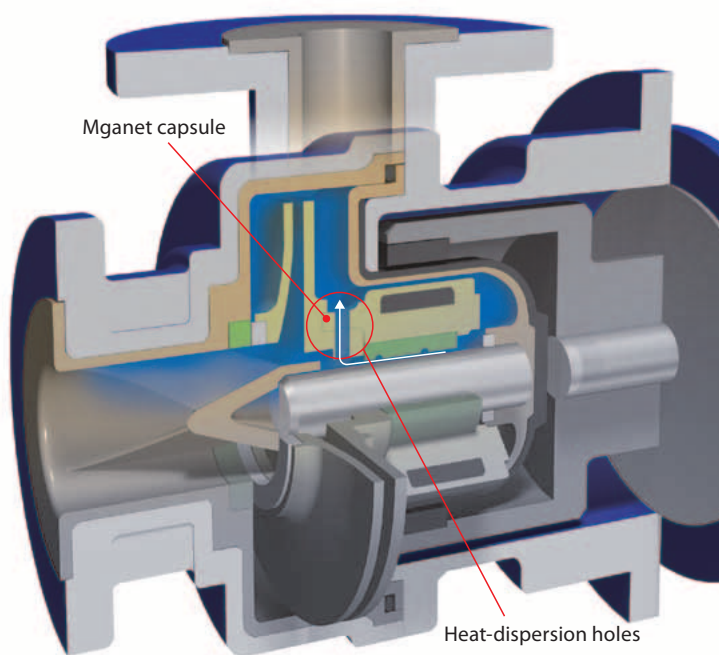
For ease of inspection and maintenance, this series employs the back pullout system. This enables one to conduct inspections internally and replace parts without removing piping. The pump is designed to include safety measures that prevent the liquid from leaking when the foot support is pulled back.

Note: Pump base plate is required for the back pull-out system.



Self radiation structure (Pat.)

MXM



Internal flow circulation in the pump chamber is required in order to lubricate and cool bearings. In the case of abnormal operation such as “cavitation” or “air-sucking operation”, internal flow circulation can not work properly because the balance of the pressure in the pump chamber is unstable and seizing of bearings is possible.

Most commonly, this phenomenon occurs on small size pumps with a small flow rate range. Therefore, heat dispersion holes are included in the magnet capsule of MXM series pumps and these holes make flow circulation smooth under abnormal operation inside of the rear casing. IWAKI refers to this design as “Self-radiating construction” (PAT).

Highly durable structure

MDW

MDE

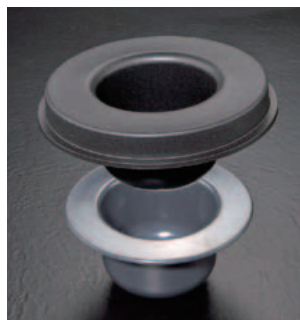
MDM

MXM

AMP

A ductile cast iron shell adds strength and durability to the Fluoroplastic wet ends. The rear casing which is subject to the highest stress, is reinforced with an FRP cover to increase strength.

Additionally, large magnetic drive pumps employ three layer construction (Pat.) to improve durability and safety, even in long-term harsh operating conditions.



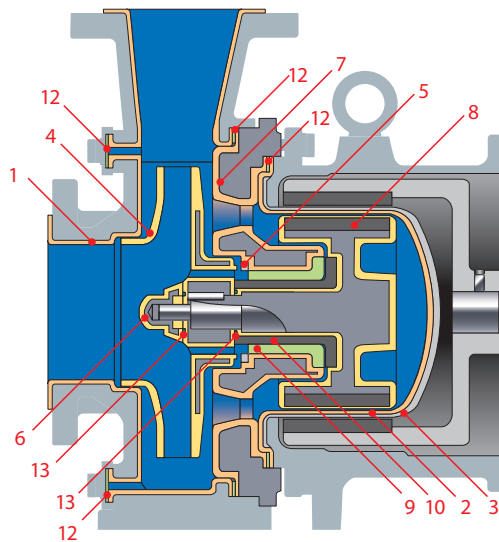
Rear casing, Rear casing cover



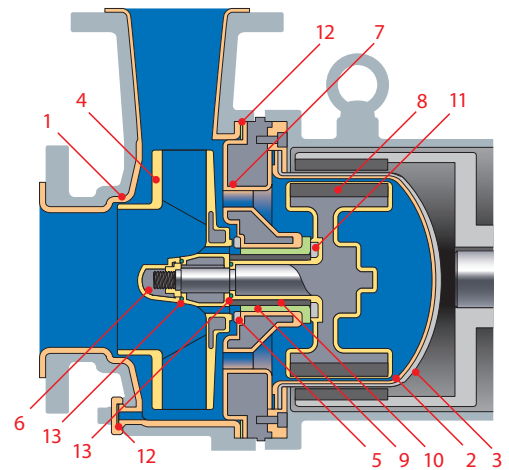
Front casing

Series lineup (by Construction and material)

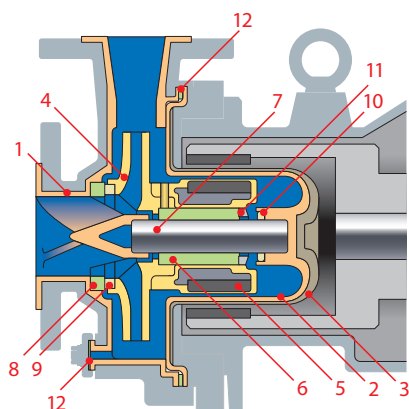
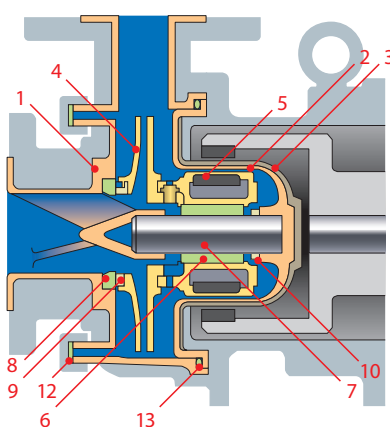
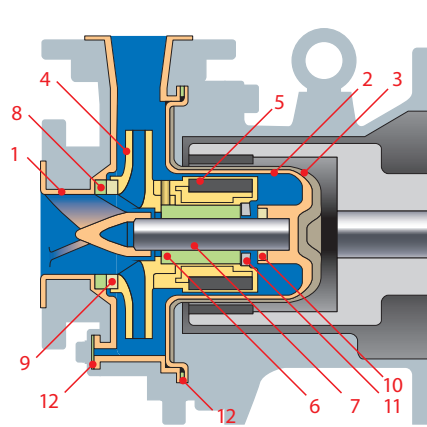
MDW



MDE

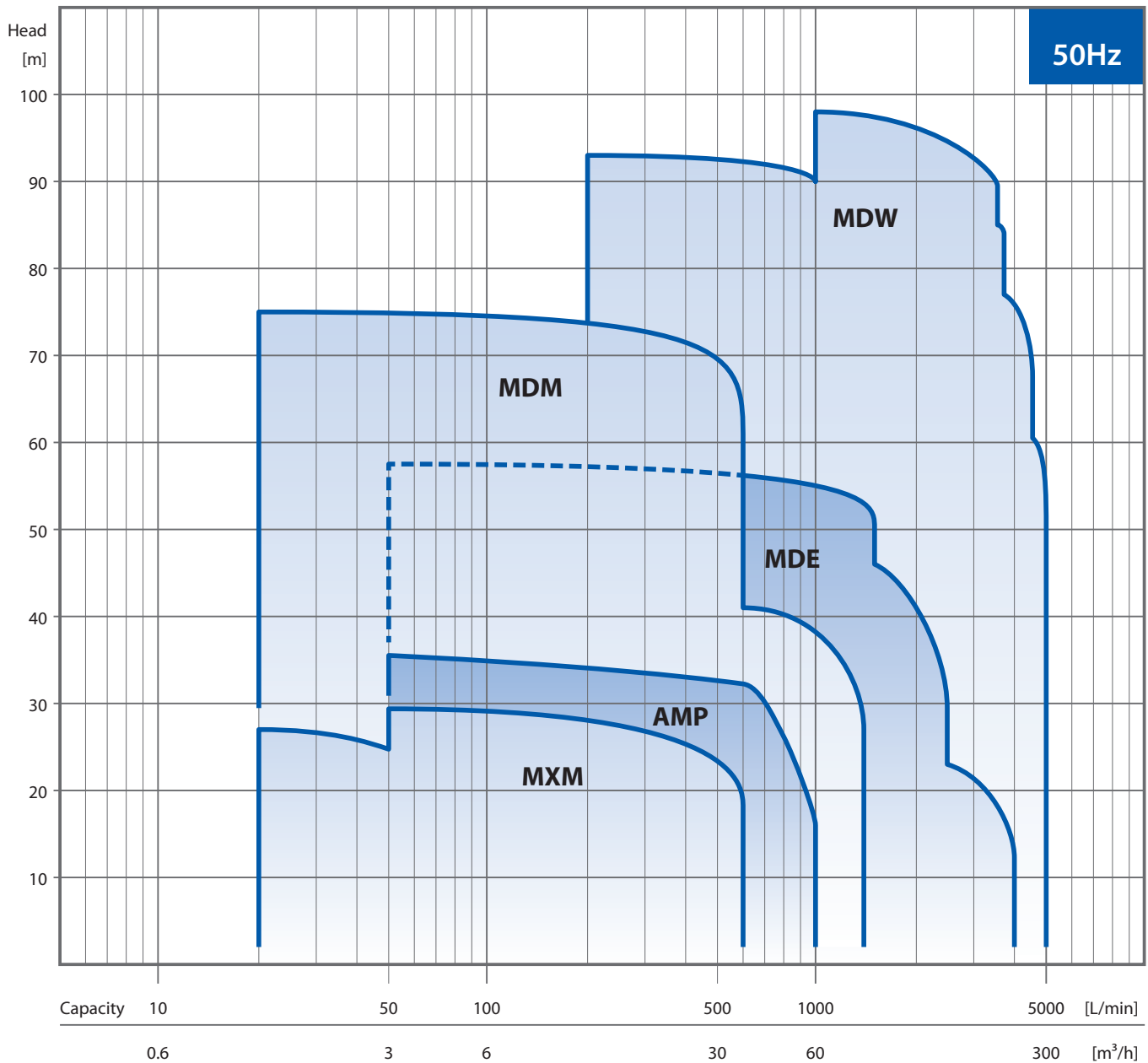


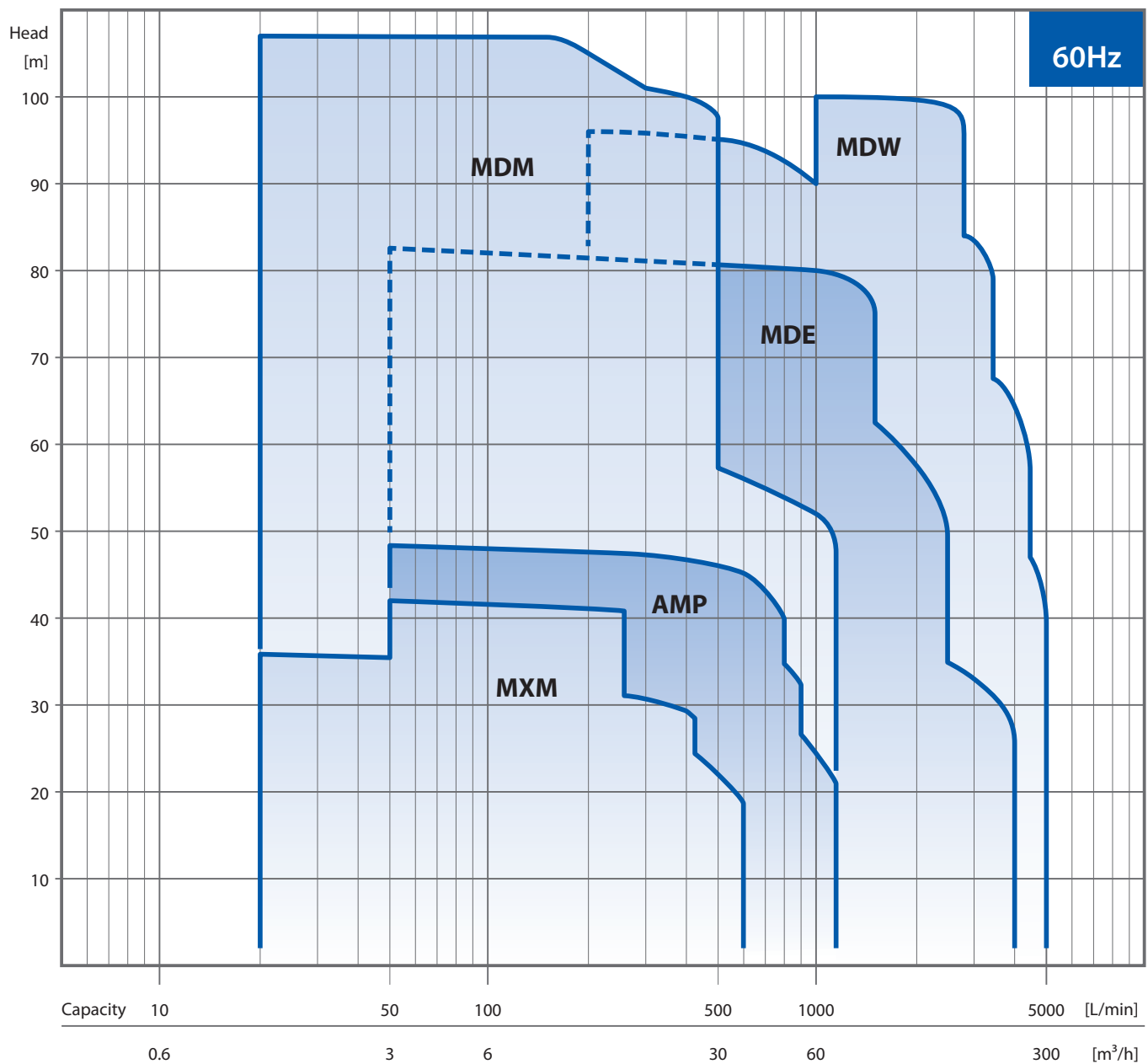
Parts	MDW	MDE
1 Front casing	ETFE, PFA	ETFE
2 Rear casing	PFA	PFA
3 Rear casing cover	FRP	FRP
4 Impeller	CFRETFE, PFA	CFRETFE
5 Impeller thrust	SiC	SiC
6 Impeller nut	PFA	CFRETFE
7 Split plate	PFA	PFA
8 Magnet capsule	PFA	PFA
9 Bearing	SiC	SiC
10 Sleeve	SiC	SiC
11 Thrust	-	SiC
12 Gasket	PTFE	PTFE
13 O ring	Kalrez®	Kalrez®, FKM, EPDM

MDM**MXM****AMP**

Part names	MDM	MXM	AMP
1 Front casing	CFRETFE, PFA	CFRETFE	CFRPP
2 Rear casing	CFRETFE, PFA	CFRETFE	CFRPP
3 Rear casing cover	FRP	FRP	FRP
4 Impeller	CFRETFE, PFA	CFRETFE	CFRPP
5 Magnet capsule	CFRETFE, PFA	CFRETFE	CFRETFE
6 Bearing	High density carbon, SiC	High density carbon, SiC, High purity alumina ceramic	Carbon, SiC
7 Spindle	High purity alumina ceramic, SiC	High purity alumina ceramic, SiC	High purity alumina ceramic, SiC
8 Liner ring	High purity alumina ceramic, SiC	High purity alumina ceramic, SiC	High purity alumina ceramic, SiC
9 Mouth ring	Filled PTFE, SiC	Filled PTFE, SiC	Filled PTFE, SiC
10 Rear thrust	Filled PTFE, PTFE	CFRETFE, CFRPFA	Filled PTFE
11 Rear ring	High purity alumina ceramic, SiC	–	High purity alumina ceramic, SiC
12 Gasket	PTFE	FKM, EPDM, Aflas®, DAI-EL Perfluor®	PTFE
13 O ring	–	FKM, EPDM, Aflas®, DAI-EL Perfluor®	–

Series lineup (by Performance curve)





Note: The illustration shows the general performance. Please contact us for more details.

Topic Life-Cycle Costs

What are the costs of operating and maintaining a pump?

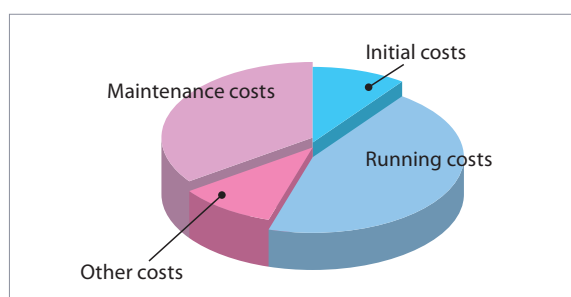
Purchase costs for a pump and electricity costs for operation are well known elements of total cost. In addition, repair costs for periodic replacement of components, failure costs associated with pump malfunctions and disposal costs of the used pump also need to be factored in to the total cost. All these costs from purchase to disposal of the pump (total costs over a pump's working life) are known as the Life-Cycle Costs (LCC).

The Life-Cycle Costs model has been developed for making a comprehensive assessment of the operating costs of a pump in order to monitor and improve the efficiency of pump operation.

$$LCC = C_{ic} + C_{in} + C_e + C_o + C_m + C_s + C_{env} + C_d$$

 C_{ic} : Initial costs (purchase costs and piping costs)
 C_{in} : Installation costs
(foundation costs and electrical work costs)
 C_e : Running costs (electricity costs and water charges)
 C_o : Operating costs
(wages and supervision costs of operators)
 C_m : Maintenance costs (maintenance and repair costs)
 C_s : Shut-down costs
(costs associated with failure and downtime)
 C_{env} : Environmental costs
(liquid waste disposal costs and leakage prevention costs)
 C_d : Disposal costs
(Various costs associated with disposal)

The pie chart below represents a breakdown of the Life-Cycle Costs of a typical shaft sealed pump. Clearly the initial costs and running costs make up more than half of the total outlay.



Surprisingly, maintenance costs represent approximately one-third of the total expenditure. This is likely due to the

high cost of parts involved in the replacement of expensive components such as shaft seals and related personnel costs.

Let's compare the Life-Cycle Costs between a typical shaft sealed pump and a plastic magnetic drive pump. With limited data, we cannot go beyond a qualitative analysis. Nevertheless, the comparison shows some interesting trends:

- Initial Cost (C_{ic}):

Magnetic drive pumps tend to cost more. This is because expensive magnetic components are used in the coupling parts and the wetted parts are molded using costly fluoroplastic materials.

- Running Costs (C_e):

Again, in many cases shaft sealed pumps seem to have a cost advantage. The reason is that the impeller and the casings of a magnetic drive pump, which could have a significant impact on pump efficiency, must be molded in resin and their configurations are limited.

In recent years, however, new solutions for reducing the running costs have been developed, by improving drive efficiency resulting from the use of high-efficiency motors and inverters.

- Maintenance Costs (C_m):

It is clear that magnetic drive pumps enjoy an overwhelming advantage. No shaft seals means no replacement of costly components, such as mechanical seals, and thus no need for skilled maintenance technicians. In addition, fluoroplastic-made materials with strong corrosion resistance will drastically reduce the need for the replacement of worn parts.

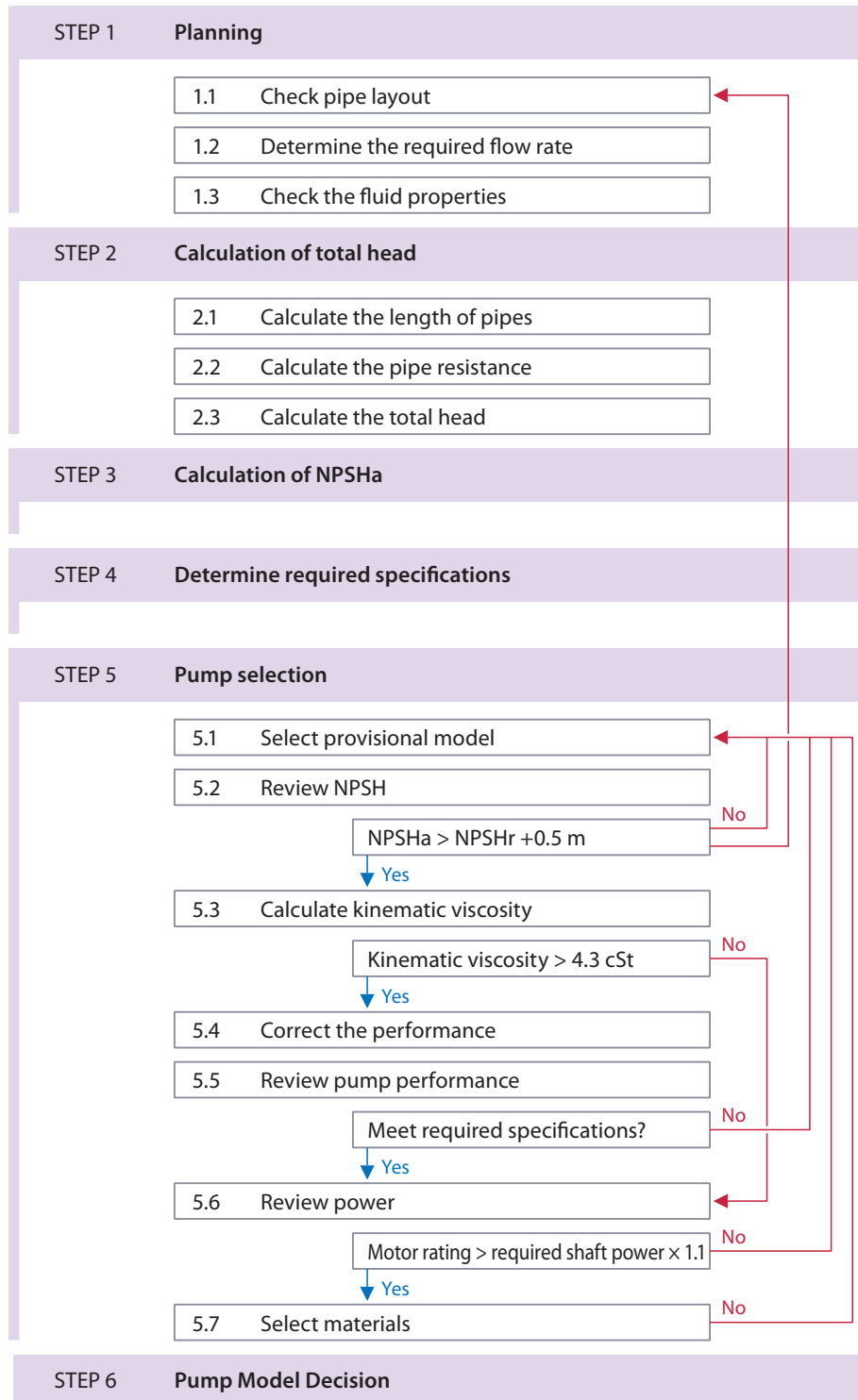
In addition, in recent years with increasing awareness of adverse environmental impacts, the costs of liquid waste disposal (C_{env}) in chemical plants are steadily growing.

Considering these factors, magnetic drive pumps with no possibility of leakage are increasing the smart choice for many demanding applications.

Model selection

Selection Procedure

The following diagram shows the overall recommended decision flow for selecting a pump.



STEP 1

Planning

Plan the overall system, from the fluid supply tank to the fluid deliver tank, in order to define the specifications for the pump.

1.1 Check pipe layout

Determine the positional relationship between the supply tank, pump, and delivery tank to determine the size and length of the connecting pipes. This will also determine the specifications of fittings, such as valves and elbow joints. The following diagram shows an example of the recommended pipe layout. The pump should be mounted in the vicinity of the supply tank. Pipework for positive inlet pressure (flooded suction) is recommended. In particular, the suction inlet pipe should be thick, short, and straight as a rule.

Refer to "Piping design tips and guide" on page 41.

1.2 Determine the required flow rate

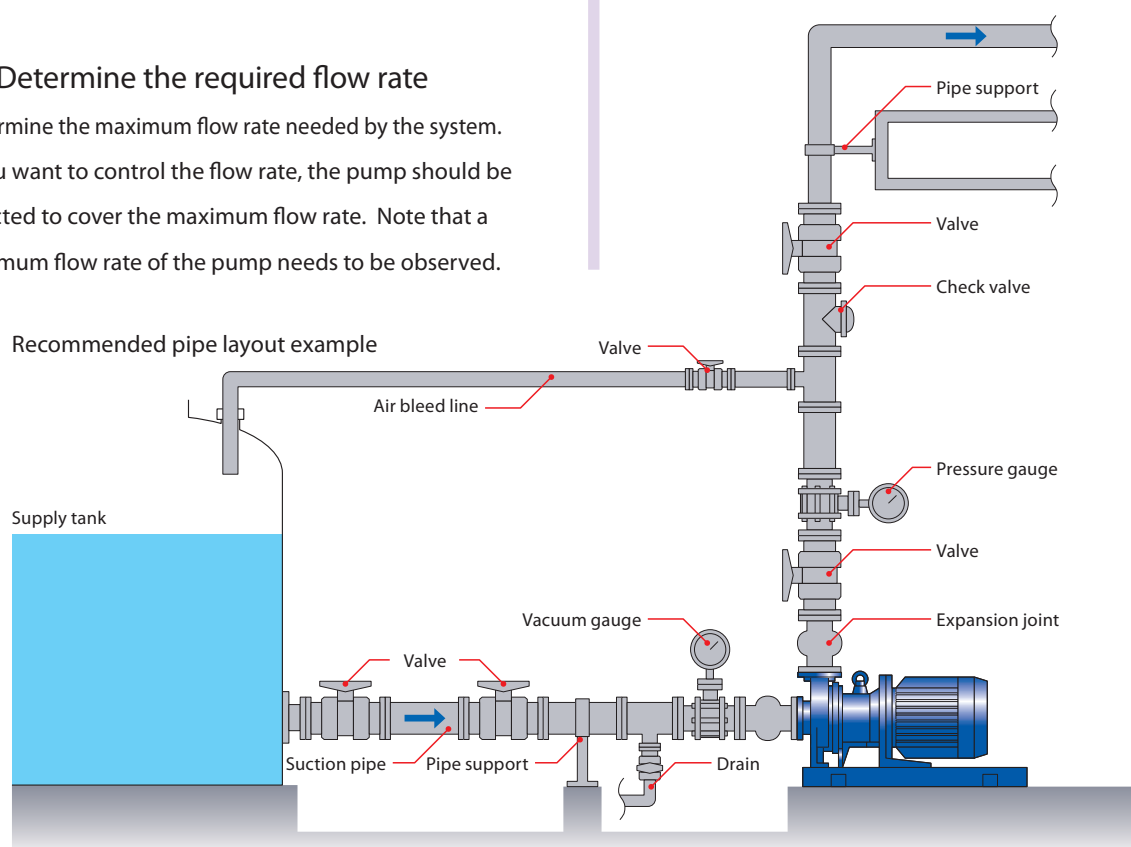
Determine the maximum flow rate needed by the system. If you want to control the flow rate, the pump should be selected to cover the maximum flow rate. Note that a minimum flow rate of the pump needs to be observed.

1.3 Check the fluid properties

Check the properties of the fluid that will be pumped including fluid name, fluid temperature, density, specific gravity, viscosity, and saturated vapor pressure.

In general, high-density and low-temperature chemicals tend to have a high viscosity. Extra precautions are required if handling hazardous chemicals, such as caustic soda and sulfuric acid, which have a high viscosity at low temperatures. If a pump is restarted some time after pumping was stopped, any increase in viscosity accompanying the temperature drop in the fluid may lead to overloading of the motor. If the fluid contains slurry, check the slurry concentration, hardness, and grain size. Magnetic pumps made of plastics are generally unsuitable for pumping slurry. Additional steps for removing slurry before the magnetic pump are recommended.

Refer to "Specific Gravity/Viscosity of Major Fluids" on page 51, and "Chemicals Requiring Caution" on page 47.



STEP 2 Calculation of total head

Calculate the total system head based on the pipe layout and the required flow rate.

2.1 Calculate the length of pipes

Calculate the combined length of the suction inlet pipe and discharge outlet pipe based on the pipe layout.

Elbow joints, valves, and other fittings will introduce a higher pipe resistance compared to a corresponding straight section of pipe, and these must be converted to equivalent lengths of straight pipe for calculating the pipe resistance. This virtual pipe length is referred to as the "equivalent length".

Refer to "Equivalent straight pipe length of typical couplings" on page 45.

2.2 Calculate the pipe resistance

Determine the flow velocity from the pipe diameter and the flow rate. Then calculate the pipe resistance (friction head loss) for the flow velocity. The pipe resistance is calculated using the Darcy-Weisbach equation.

$$\text{Pipe resistance: } H_f = f \frac{L}{D} \frac{V^2}{2g} \quad [\text{m}]$$

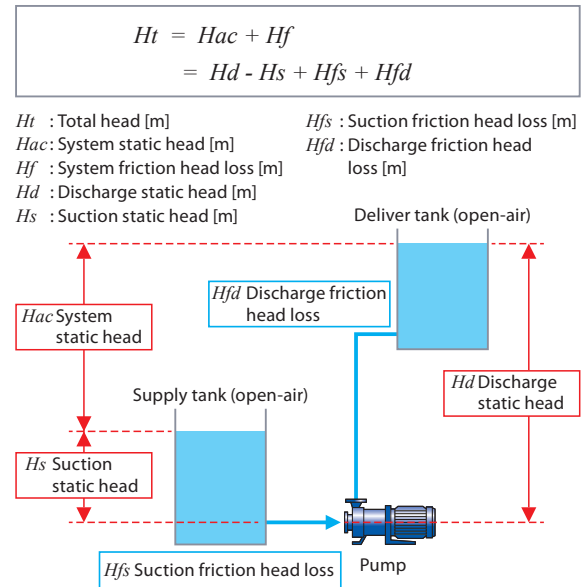
f : Friction coefficient (0.02 + 0.0005/D for new pipes)
 L : Pipe length [m]
 D : Pipe diameter [m] (use the inner diameter)
 V : Fluid velocity [m/s]
 g : Acceleration of gravity [9.8 m/s²]

You can use the "Quick reference chart for pipe resistance" on page 46 to determine pipe resistance, but for accurate results it is recommended that it be calculated directly from the equation above if you are able to determine the inside diameter of the pipe.

2.3 Calculate the total head

The total system head is the sum of the pipe resistance and the difference in elevation of the fluid surfaces in the supply tank and the deliver tank.

- If the tanks are open-air. The pressure in each tank is the atmospheric pressure.

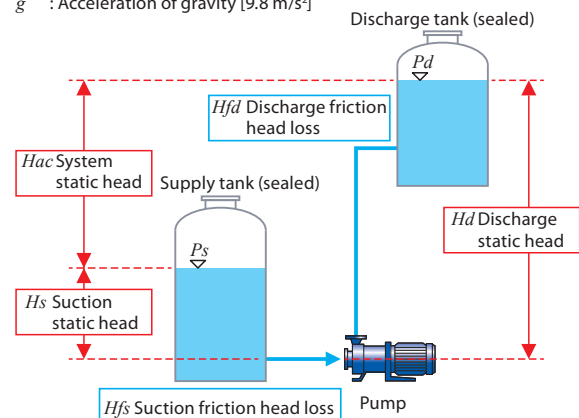


- If the tanks are sealed. The pressure differential inside the tanks must be included in the calculation.

$$H_t = H_{ac} + H_f + \frac{(P_d - P_s) \times 10^6}{\rho g} \quad [\text{m}]$$

$$= H_d - H_s + H_{fs} + H_{fd} + \frac{(P_d - P_s) \times 10^6}{\rho g} \quad [\text{m}]$$

H_t : Total head [m]
 H_{ac} : System static head [m]
 H_f : System friction head loss [m]
 P_d : Pressure inside output tank [MPa]
 P_s : Pressure inside supply tank [MPa]
 ρ : Fluid density [kg/m³]
 g : Acceleration of gravity [9.8 m/s²]
 H_d : Discharge static head [m]
 H_s : Suction static head [m]
 H_{fs} : Suction friction head loss [m]
 H_{fd} : Discharge friction head loss [m]



STEP 3 Calculation of NPSHa

Calculate the NPSHa and review the suction conditions.

NPSH (Net Positive Suction Head) is a value of the energy pushing fluid into the suction inlet of a running pump expressed in units of head [m]. It is an important value that must be considered to prevent cavitation. Here, we calculate the NPSHa (NPSH available) from the fluid properties and pipe conditions. This value will then be compared with the NPSHr (NPSH required) which is a characteristic of the pump in STEP 5.

NPSHa is calculated using the following equation.

$$\text{NPSHa} = \frac{(P_A - P_V) \times 10^6}{\rho g} \pm H_s - H_{fs} \text{ [m]}$$

P_A : Absolute pressure on surface fluid in the supply tank [MPa]

If the tank is open to the atmosphere,
(nominally standard atmospheric pressure) = 0.1013 [MPa]

P_V : Fluid vapor pressure at the pump inlet temperature [MPa]

H_s : Suction static head (height of inlet port center relative to supply tank fluid level) [m]

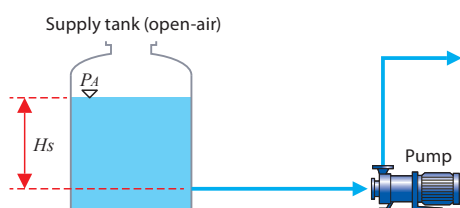
(Flooded is positive, Lift-up is negative)

H_{fs} : Suction friction head loss [m]

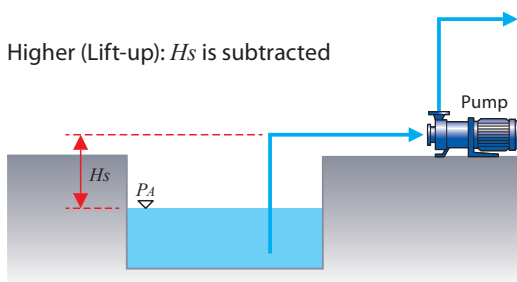
ρ : Fluid density [kg/m³]

g : Acceleration of gravity [9.8 m/s²]

Lower (Flooded): H_s is added



Higher (Lift-up): H_s is subtracted



STEP 4 Determine required specifications

Summarize the information required for selecting a pump based on the information obtained thus far.

Required specification

Discharge rate (nominal)	___ L/min
Suction rate (maximum)	___ L/min
Total head	___ m
Discharge head	___ m
Suction head	___ m
NPSHa	___ m
Location	Indoor/Outdoor
Operation mode	Continuous/Intermittent ___ hr/day
Supply voltage, frequency	___ V ___ Hz

Fluid handling

Fluid name	___
Concentration	___ %
Temperature	___ °C
Viscosity	___ mPa·s
Specific gravity	___
Saturated vapor pressure	___ kPa
Slurry	Yes/No
Slurry concentration, particle size, hardness	___ wt%, ___ μm, ___ Hs

STEP 5

Pump selection

With the required information summarized, we can proceed to select a pump.

5.1 Select provisional model

Select a pump that satisfies the required conditions from the product catalog or from individual standard performance curves.

Refer to the performance curves in the series overview on page 17. The standard performance curves for each model must be checked separately. Contact IWAKI for more information.

5.2 Review NPSH

The NPSHr required for a pump is determined individually for each model of pump, and can be read from the individual standard performance curves. In order to avoid cavitation, the NPSHa must be greater than the NPSHr. In addition, it is also necessary to have a margin of more than 0.5m above the NPSHa. Therefore, check that the following condition is satisfied.

$$\text{NPSHa} > \text{NPSHr} + 0.5$$

If the NPSHr is insufficient, return to STEP 1.1 and see if you can resolve the problem by reviewing the pipework conditions or other factors. If the condition above is still not satisfied, return to STEP 5.1 and select another model with a lower NPSHr.

Refer to "Remedies when NPSHa is insufficient" on page 52.

5.3 Calculate kinematic viscosity

Calculate the kinematic viscosity from the fluid viscosity and density.

$$\text{Kinematic viscosity: } \nu = \frac{\mu}{\rho} \times 10^3 \text{ [m}^2\text{/s]}$$

ν : Kinematic viscosity [m²/s] or [cSt]

μ : Viscosity [mPa·s] or [cP]

ρ : Density [kg/m³] = γ : Specific gravity $\times 10^3$

- When the kinematic viscosity ν is less than 4.3, effects of viscosity on pump performance can be ignored. Proceed to STEP 5.6.
- When the kinematic viscosity ν is greater than 4.3, viscosity will affect pump performance, and performance revision is required. Proceed to STEP 5.4.

However, if the specific gravity of the fluid is greater than 1, even if the kinematic viscosity is less than 4.3, the power rating will need to be modified.

5.4 Correct performance

Refer to the flow rate and head at the point of maximum efficiency of the pump from the standard performance curves. Read the viscosity correction factor (head Ch , flow rate Cq , efficiency Ce) from the performance correction curve.

Refer to "Performance correction curve" on page 53.

Calculate the revised shaft power from the individual correction factors

$$\text{Corrected head} = H_w \times Ch$$

$$\text{Corrected flow rate} = Q_w \times Cq$$

$$\text{Corrected efficiency} = E_w \times Ce$$

Corrected shaft power

$$= \frac{0.163 \times \text{Specific gravity} \times \text{Corrected head [m]} \times \text{Corrected flow rate [L/min]}}{\text{Corrected efficiency [\%]} / 100} \times 10^{-3}$$

5.5 Review pump performance

Check whether the calculated corrected performance satisfies the required specifications.

If the required specifications are not satisfied, the performance must be reviewed again from STEP 5.1.

5.6 Review power

Calculate the shaft power and review the size of motor to connect to the pump.

$$\text{Required shaft power: } SP = \frac{0.163 \gamma Q H}{\eta / 100} \times 10^{-3} \text{ [kW]}$$

γ : Specific gravity
 Q : Flow rate [L/min]
 H : Head [m]
 η : Pump efficiency [%]

The shaft power of the pump should be larger than calculated to cover changes in operating point, type of fluid, or other factors. A margin of at least 10% is recommended to maintain normal operation.

Select a pump with an equivalent or higher rated output motor from the product lineup.

5.7 Select materials

Select the materials of wet ends the handled fluid.

Consider the optimal combination of corrosion resistance, model, series structure, and other factors.

For models and series structure of each type of pump, Refer to "Product Specifications" on page 58.

STEP 6

Pump Model Decision

Refer to the connection flange standards, drain requirement, and pump base plate requirement of the specifications.

Note that a pump base is required to use the back pullout configuration for maintenance. A drain may also be required, depending on the installation location and the type of maintenance performed.

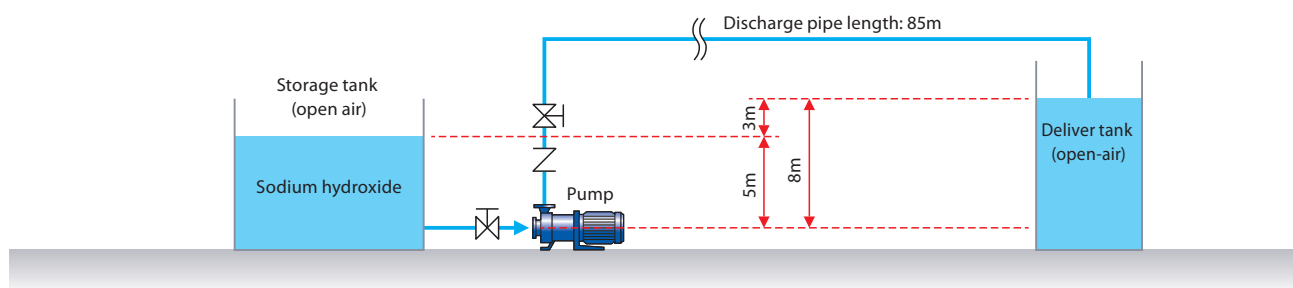
Finally, select the pump model based on above consideration.

Selection example 1 (Sodium hydroxide)

Here we will consider some actual case studies, and follow the procedure to select a pump.

In this example, sodium hydroxide is pumped to a process line from a storage tank located some distance away.

The static head is low, and the discharge pipe length is long.



STEP 1

Planning

1.1 Check pipe layout

H_s	: Suction static head	5 [m]
H_d	: Discharge static head	8 [m]
H_{ac}	: System static head	3 [m]

1.2 Determine the required flow rate

Nominal flow rate	: 3000 [L/min]
Maximum flow rate	: 3000 [L/min]
Required flow rate $Q =$	: 3000 [L/min]

1.3 Check the fluid properties

Fluid handling	
Fluid name	Sodium hydroxide (NaOH)
Concentration	20 %
Temperature	20 °C
Viscosity	4.43 mPa·s
Specific gravity	1.22
Saturated vapor pressure	2.2 kPa
Slurry	No

STEP 2

Calculation of total head

2.1 Calculate the length of pipes

Suction pipe

Type	Qty	Size	Equivalent length
Straight pipe	1	125A	5 m
Gate valve (flange)	1	125A	1 m

Total 6 [m]

Discharge pipe

Type	Qty	Size	Equivalent length
Straight pipe	1	100A	85 m
Gate valve (flange)	1	100A	0.9 m
90° elbow (flange)	2	100A	3.6 m
Swing check valve (flange)	1	100A	11.6 m

Total 101.1 [m]

2.2 Calculate the pipe resistance

Calculate the flow velocity in the suction pipe and discharge pipe from the pipe diameter and flow rate.

Suction pipe D : Pipe inner diameter 0.125 [m] S : Cross-sectional area 0.012272 [m²] Q : Flow rate 0.05 [m³/s]Suction pipe flow velocity: $V = \frac{Q}{S} = 4.07$ [m/s]**Discharge pipe** D : Pipe inner diameter 0.1 [m] S : Cross-sectional area 0.007854 [m²] Q : Flow rate 0.05 [m³/s]Discharge pipe flow velocity: $V = \frac{Q}{S} = 6.37$ [m/s]

Calculate the pipe resistance of the suction pipe and discharge pipe. The pipe resistance is calculated using the Darcy-Weisbach equation.

$$\text{Pipe resistance: } H_f = f \frac{L}{D} \frac{V^2}{2g} \text{ [m]}$$

Suction pipe f : Friction coefficient (0.02 + 0.0005/ D for new pipes) L : Pipe length 6 [m] D : Pipe inner diameter 0.125 [m] V : Fluid velocity 4.07 [m/s] g : Acceleration of gravity [9.8 m/s²]Suction friction head loss: $H_{fs} = 0.97$ [m]**Discharge pipe** f : Friction coefficient (0.02 + 0.0005/ D for new pipes) L : Pipe length 101.1 [m] D : Pipe inner diameter 0.1 [m] V : Fluid velocity 6.37 [m/s] g : Acceleration of gravity [9.8 m/s²]Discharge friction head loss: $H_{fd} = 52.33$ [m]**2.3 Calculate the total head**

In this example, both tanks are open-air. The total head is given by the following equation.

$$\text{Total head } H_t = H_{ac} + H_{fs} + H_{fd} \text{ [m]}$$

 H_{ac} : System static head 3 m H_{fs} : Suction friction head loss 0.97 m H_{fd} : Discharge friction head loss 52.33 mTotal head $H_t = 56.3$ [m]**STEP 3****Calculation of NPSHa**

Calculate the NPSHa and review the suction conditions.

For open-air tanks, the NPSHa is given by the following equation.

$$\text{NPSHa} = \frac{(P_A - P_v) \times 10^6}{\rho g} \pm H_s - H_{fs} \text{ [m]}$$

 P_A : Atmospheric pressure 0.1013 [MPa] P_v : Saturated vapor pressure 2.2 [kPa] = 0.0022 [MPa] H_s : Suction static head 5 [m] H_{fs} : Suction friction head loss 0.97 [m] ρ : Fluid density 1220 [kg/m³] (Specific gravity 1.22) g : Acceleration of gravity [9.8 m/s²]

NPSHa = 12.3 [m]

STEP 4**Determine required specifications**

Summarize the information obtained thus far.

Required specification

Discharge rate (nominal)	3000 L/min
Suction rate (maximum)	3000 L/min
Total head	56.3 m
Discharge head	5 m
Suction head	8 m
NPSHa	12.3 m
Location	Indoor
Operation mode	2 hr/day
Supply voltage, frequency	400 V, 50 Hz
Connection standard	JIS 10K
Pump drain	Required
Pump base	Required

Fluid handling

Fluid name	Sodium hydroxide
Concentration	20 %
Temperature	20 °C
Viscosity	4.48 mPa·s
Specific gravity	1.22
Saturated vapor pressure	2.2 kPa
Slurry	No

STEP 5

Pump selection

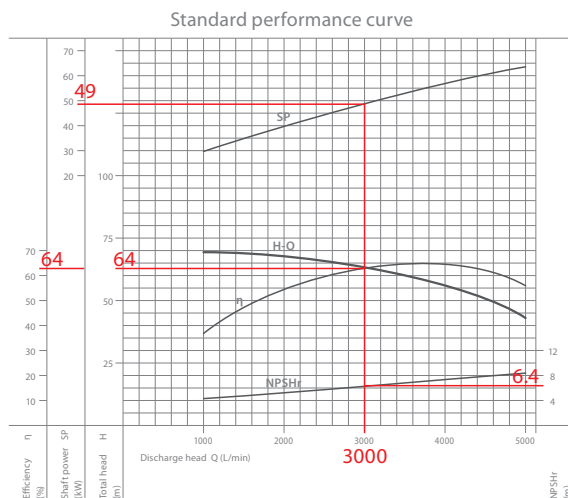
5.1 Select provisional model

Select a pump that satisfies the required conditions from a product catalog or from individual standard performance curves.

In this case, the following model is selected.

Provisional model:
MDW 100 - 200 _ _ _ _ _ - _ 2

Check the pump performance with the required specifications using the standard performance curves for the selected pump.



Q	: Flow rate	3000 [L/min]
H	: Head	64 [m]
SP	: Shaft power	49 [kW]
η	: Efficiency	64 [%]
NPSHr	:	6.4 [m]

5.2 Review NPSH

NPSHa=10.3 [m], NPSHr=6.4 [m]

$$NPSHa > NPSHr + 0.5$$

The calculated NPSHa and NPSHr satisfy the above relationship

5.3 Calculate kinematic viscosity

$$\text{Kinematic viscosity: } \nu = \frac{\mu}{\rho} \times 10^3$$

μ : Viscosity 4.43 [mPa·s] or [cP]
 ρ : Density 1220 [kg/m³] (Specific gravity $\times 10^3$)

Kinematic viscosity: $\nu = 3.63$ [cSt]

In this case, the kinematic viscosity ν is less than 4.3, so the impact on pump performance due to viscosity can be ignored. However, if the fluid viscosity is greater than 1, the power specification needs to be revised. Proceed to step 5.6.

5.4 Correct performance

Not required in this case.

5.5 Review pump performance

Not required in this case.

5.6 Review power

Calculate the shaft power and review the size of motor to connect to the pump.

$$\text{Required shaft power: } SP = \frac{0.163 \gamma Q H}{\eta / 100} \times 10^{-3} \text{ [kW]}$$

γ : Specific gravity 1.22
 Q : Flow rate 3000 [L/min]
 H : Head 64 [m]
 η : Pump efficiency 64 [%]

Required shaft power: $SP = 59.7$ [kW]

The shaft power of the pump should be larger than planned to cover any changes in operating point, type of fluid, or other cause, hence a margin of at least 10% should be maintained for normal operation.

Calculate a revised shaft power by adding a 10% safety margin to the calculated required shaft power.

Corrected shaft power: $SP = 59.8 \times 1.1 = 65.7$ [kW]

Therefore, the required motor size must deliver 65.8 kW or higher. Select a pump with 75 kW rated output from the product lineup.

5.7 Select materials

Select the materials of wet ends for the handled fluid.

The only material available for MDW pump spindle-bearing is an SiC-SiC combination, which can be used with Sodium Hydroxide.

The O-ring material is the standard Kalrez®, which can also be used with caustic soda. Therefore, the material symbol in the model name is EKZ.

STEP 6 Pump Model Decision

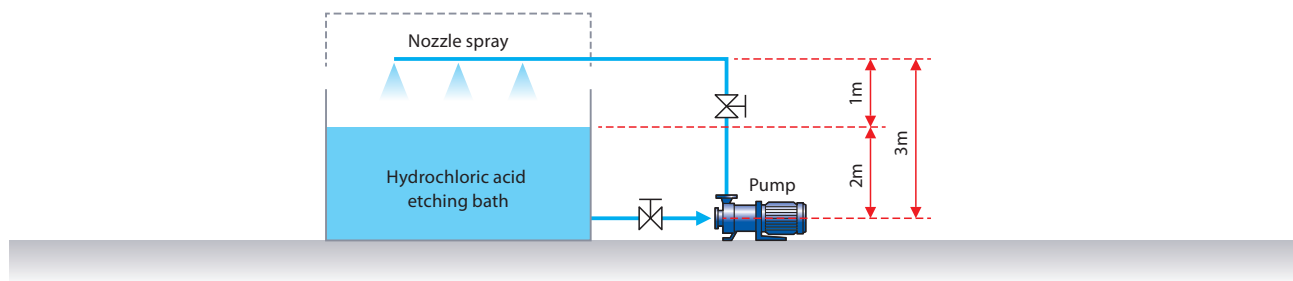
Check the required flange connection standard and the requirements for pump drain and pump base before making a final decision on the pump model.

Selected model:
MDW 100 - 200 E K Z C 750 J - D 2

Selection example 2 (Hydrochloric acid)

In this example, the discharge is hydrochloric acid spray used in the etching process.

The pressure of the nozzle tip on the discharge side must be taken into account.



STEP 1

Planning

1.1 Check pipe layout

H_s	: Suction static head	2 [m]
H_d	: Discharge static head	3 [m]
H_{ac}	: System static head	1 [m]
Nozzle tip pressure:		0.2 [MPa]

1.2 Determine the required flow rate

Required flow rate $Q =$: 300 [L/min]

1.3 Check the fluid properties

Fluid handling

Fluid name	Hydrochloric acid (HCl)
Concentration	30 wt%
Temperature	20 °C
Viscosity	1.73 mPa·s
Specific gravity	1.15
Saturated vapor pressure	2.2 kPa
Slurry	No

STEP 2

Calculation of total head

2.1 Calculate the length of pipes

Suction pipe

Type	Qty	Size	Equivalent length
Straight pipe	1	50 A	1 m
Gate valve (screw)	1	50 A	0.5 m
			Total 1.5 [m]

Discharge pipe

Type	Qty	Size	Equivalent length
Straight pipe	1	40 A	7 m
Gate valve (screw)	1	40 A	0.4 m
90° elbow (screw)	1	40 A	2.3 m
			Total 9.7 [m]

2.2 Calculate the pipe resistance

Calculate the flow velocity in the suction pipe and discharge pipe from the pipe diameter and flow rate.

Suction pipe

D : Pipe inner diameter	0.05 [m]
S : Cross-sectional area	0.001963 [m ²]
Q : Flow rate	0.005 [m ³ /s]

$$\text{Suction pipe flow velocity: } V = \frac{Q}{S} = 2.55 \text{ [m/s]}$$

Discharge pipe

D : Pipe inner diameter	0.04 [m]
S : Cross-sectional area	0.001257 [m ²]
Q : Flow rate	0.005 [m ³ /s]

$$\text{Discharge pipe flow velocity: } V = \frac{Q}{S} = 3.98 \text{ [m/s]}$$

Calculate the pipe resistance of the suction pipe and discharge pipe. The pipe resistance is calculated using the Darcy-Weisbach equation.

$$\text{Pipe resistance: } H_f = f \frac{L}{D} \frac{V^2}{2g} \text{ [m]}$$

Suction pipe

f : Friction coefficient (0.02 + 0.0005/D for new pipes)	
L : Pipe length	1.5 [m]
D : Pipe inner diameter	0.05 [m]
V : Fluid velocity	2.55 [m/s]
g : Acceleration of gravity	[9.8 m/s ²]

$$\text{Suction friction head loss: } H_{fs} = 0.30 \text{ [m]}$$

Discharge pipe

f : Friction coefficient (0.02 + 0.0005/D for new pipes)	
L : Pipe length	9.7 [m]
D : Pipe inner diameter	0.04 [m]
V : Fluid velocity	3.98 [m/s]
g : Acceleration of gravity	[9.8 m/s ²]

$$\text{Discharge friction head loss: } H_{fd} = 6.36 \text{ [m]}$$

2.3 Calculate the total head

In this example, the tank is open-air. Calculate the total head taking into account the nozzle tip pressure.

$$\text{Total head } H_t = H_{ac} + H_{fs} + H_{fd} \text{ [m]}$$

H_{ac} : System static head	1 m	
H_{fs} : Suction friction head loss	0.3 m	
H_{fd} : Discharge friction head loss	6.36 m	Total head $H_t = 7.7$ [m]

Taking into account the 0.2 [MPa] nozzle tip pressure:

$$7.7 + \frac{0.2}{\rho g} \times 10^6$$

$$= \text{Total head } H_t = 25.4 \text{ [m]}$$

STEP 3**Calculation of NPSHa**

Calculate the NPSHa and review the suction conditions.

For open-air tanks, the NPSHa is given by the following equation.

$$\text{NPSHa} = \frac{(P_A - P_v) \times 10^6}{\rho g} \pm H_s - H_{fs} \text{ [m]}$$

P_A : Atmospheric pressure	0.1013 [MPa]
P_v : Saturated vapor pressure	2.2 [kPa] = 0.0022 [MPa]
H_s : Suction static head	2 [m]
H_{fs} : Suction friction head loss	0.3 [m]
ρ : Fluid density	1150 [kg/m ³] (Specific gravity 1.15)
g : Acceleration of gravity	[9.8 m/s ²]

$$\text{NPSHa} = 10.49 \text{ [m]}$$

STEP 4**Determine required specifications**

Summarize the information obtained thus far.

Required specification

Discharge rate (nominal)	300 L/min
Suction rate (maximum)	300 L/min
Total head (including nozzle tip pressure)	25.4 m
Discharge static head	3 m
Suction static head	2 m
NPSHa	10.5 m
Location	Outdoor
Operation mode	24 hr/day
Supply voltage, frequency	200 V, 50 Hz
Connection standard	JIS 10K
Pump drain	Not required
Pump base	Required

Fluid handling

Fluid name	Hydrochloric acid
Concentration	30 wt%
Temperature	20 °C
Viscosity	1.73 mPa·s
Specific gravity	1.15
Saturated vapor pressure	2.2 kPa
Slurry	No

STEP 5

Pump selection

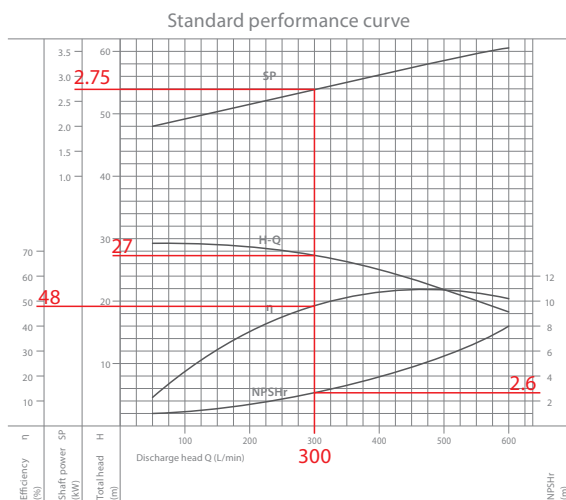
5.1 Select provisional model

Select a pump that satisfies the required conditions from a product catalog or from individual standard performance curves.

In this case, the following model is selected.

Provisional model:
MXM 54 _ - 1504 _ _ _ _ - _

Check the pump performance with the required specifications using the standard performance curves of the selected pump.



Q	: Flow rate	300 [L/min]
H	: Head	27 [m]
SP	: Shaft power	2.75 [kW]
η	: Efficiency	48 [%]
NPSHr	:	2.6 [m]

5.2 Review NPSH

NPSHa=10.5 [m], NPSHr=2.6 [m]

$$NPSHa > NPSHr + 0.5$$

The calculated NPSHa and NPSHr satisfy the above relationship

5.3 Calculate kinematic viscosity

$$\text{Kinematic viscosity: } \nu = \frac{\mu}{\rho} \times 10^3$$

μ : Viscosity 1.73 [mPa·s] or [cP]

ρ : Density 1150 [kg/m³] (Specific gravity $\times 10^3$)

Kinematic viscosity $\nu = 1.5$ [cSt]

In this case, the kinematic viscosity ν is less than 4.3, so the impact on pump performance due to viscosity can be ignored. However, if the fluid viscosity is greater than 1, the power specification needs to be revised. Proceed to step 5.6.

5.4 Correct performance

Not required in this case.

5.5 Review pump performance

Not required in this case.

5.6 Review power

Calculate the shaft power and review the size of motor to connect to the pump.

$$\text{Required shaft power: } SP = \frac{0.163 \gamma Q H}{\eta / 100} \times 10^{-3} \text{ [kW]}$$

γ : Specific gravity 1.15

Q : Flow rate 300 [L/min]

H : Head 27 [m]

η : Pump efficiency 48 [%]

Required shaft power: $SP = 3.16$ [kW]

The shaft power of the pump should be larger than planned to cover any changes in operating point, type of fluid, or other cause, hence a margin of at least 10% should be maintained for normal operation.

Calculate a revised shaft power by adding a 10% safety margin to the calculated required shaft power.

$$\text{Corrected shaft power: } SP = 3.16 \times 1.1 = 3.48 \text{ [kW]}$$

Therefore, the required motor size must deliver 3.48 kW or higher. Select a pump with 3.7 kW rated output from the product lineup.

5.7 Select materials

Select the materials that can be used for wet ends for the handled fluid.

The following options are available for selecting the bearing/spindle material for MXM pumps.

Bearing/spindle material	
CF type	Carbon/Alumina ceramics
FF type	Alumina ceramics/Alumina ceramics
KK type	SiC/SiC

The CF type combination is recommended for its dry-running capability.

The following options are available for the O-ring material.

O-ring material	
V type	FKM (Fluoro Rubber)
A type	AFLAS®

E type (EPDM) is also available, but it is not suitable for acidic chemicals. In this example, select V type.

Therefore, the material symbol in the model name is E CF V.

STEP 6

Pump Model Decision

Check the required flange connection standard and the requirements for pump drain and pump base before making a final decision on the pump model.

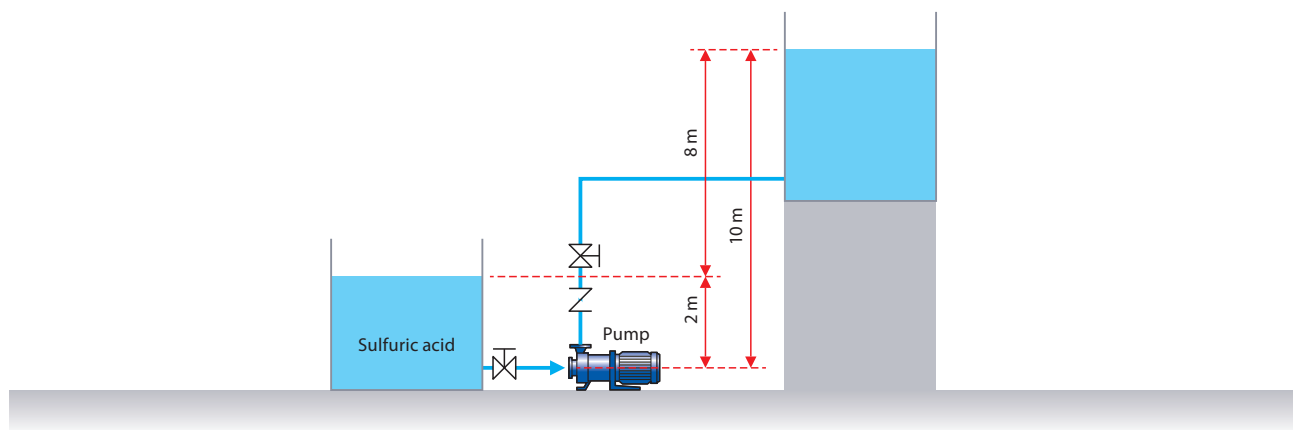
Selected model:

MXM 545 - 1504 E CF V J - B

Selection example 3 (Sulfuric acid)

In this example, the pumps transport sulfuric acid. Sulfuric acid is a slightly viscous liquid.

Kinematic viscosity, in particular, must be checked.



STEP 1

Planning

1.1 Check pipe layout

H_s	: Suction static head	2 [m]
H_d	: Discharge static head	10 [m]
H_{ac}	: System static head	8 [m]

1.2 Determine the required flow rate

Nominal flow rate	: 400 [L/min]
Maximum flow rate	: 400 [L/min]
Required flow rate $Q =$	: 400 [L/min]

1.3 Check the fluid properties

Fluid handling	
Fluid name	Sulfuric acid (H_2SO_4)
Concentration	98 wt%
Temperature	25 °C
Viscosity	26 mPa·s
Specific gravity	1.84
Saturated vapor pressure	0.0001 kPa
Slurry	No

STEP 2

Calculation of total head

2.1 Calculate the length of pipes

Suction pipe

Type	Qty	Size	Equivalent length
Straight pipe	1	50A	5 m
Gate valve (flange)	1	50A	0.5 m

Total 5.5 [m]

Discharge pipe

Type	Qty	Size	Equivalent length
Straight pipe	1	40 A	18 m
Check valve (screw)	1	40 A	4.6 m
Gate valve (screw)	1	40 A	0.4 m
90° elbow (screw)	1	40 A	2.3 m

Total 25.3 [m]

2.2 Calculate the pipe resistance

Calculate the flow velocity in the suction pipe and discharge pipe from the pipe diameter and flow rate.

Suction pipe

D : Pipe inner diameter	0.05 [m]
S : Cross-sectional area	0.001963 [m ²]
Q : Flow rate	0.00667 [m ³ /s]

$$\text{Suction pipe flow velocity: } V = \frac{Q}{S} = 3.40 \text{ [m/s]}$$

Discharge pipe

D : Pipe inner diameter	0.04 [m]
S : Cross-sectional area	0.001257 [m ²]
Q : Flow rate	0.00667 [m ³ /s]

$$\text{Discharge pipe flow velocity: } V = \frac{Q}{S} = 5.31 \text{ [m/s]}$$

Calculate the pipe resistance of the suction pipe and discharge pipe. The pipe resistance is calculated using the Darcy-Weisbach equation.

$$\text{Pipe resistance: } Hf = f \frac{L}{D} \frac{V^2}{2g} \text{ [m]}$$

Suction pipe

f : Friction coefficient (0.02 + 0.0005/D for new pipes)	
L : Pipe length	5.5 [m]
D : Pipe inner diameter	0.05 [m]
V : Fluid velocity	3.40 [m/s]
g : Acceleration of gravity	[9.8 m/s ²]

$$\text{Suction friction head loss: } Hfs = 1.94 \text{ [m]}$$

Discharge pipe

f : Friction coefficient (0.02 + 0.0005/D for new pipes)	
L : Pipe length	23.9 [m]
D : Pipe inner diameter	0.04 [m]
V : Fluid velocity	5.31 [m/s]
g : Acceleration of gravity	[9.8 m/s ²]

$$\text{Discharge friction head loss: } Hfd = 27.9 \text{ [m]}$$

2.3 Calculate the total head

In this example, both tanks are open-air. The total head is given by the following equation.

$$\text{Total head } Ht = H_{ac} + Hfs + Hfd \text{ [m]}$$

H_{ac} : System static head	8 m
Hfs : Suction friction head loss	1.94 m
Hfd : Discharge friction head loss	27.9 m

$$\text{Total head } Ht = 37.8 \text{ [m]}$$

STEP 3**Calculation of NPSHa**

Calculate the NPSHa and review the suction conditions. For open-air tanks, the NPSHa is given by the following equation.

$$\text{NPSHa} = \frac{(P_A - P_V) \times 10^6}{\rho g} \pm H_s - Hfs \text{ [m]}$$

P_A : Atmospheric pressure	0.1013 [MPa]
P_V : Saturated vapor pressure	0.0001 [kPa] = 1.0×10^{-7} [MPa]
H_s : Suction static head	2 [m]
Hfs : Suction friction head loss	1.94 [m]
ρ : Fluid density	1840 [kg/m ³] (Specific gravity 1.84)
g : Acceleration of gravity	[9.8 m/s ²]

$$\text{NPSHa} = 5.67 \text{ [m]}$$

STEP 4**Determine required specifications**

Summarize the information obtained thus far.

Required specification

Discharge rate (nominal)	400 L/min
Suction rate (maximum)	400 L/min
Total head	37.8 m
Discharge static head	10 m
Suction static head	2 m
NPSHa	5.67 m
Location	Outdoor
Operation mode	8 hr/day
Supply voltage, frequency	200 V, 50 Hz
Connection standard	JIS 10K
Pump drain	Required
Pump base	Required

Fluid handling

Fluid name	Sulfuric acid
Concentration	98 wt%
Temperature	25 °C
Viscosity	26 mPa·s
Specific gravity	1.84
Saturated vapor pressure	0.0001 kPa
Slurry	No

STEP 5

Pump selection

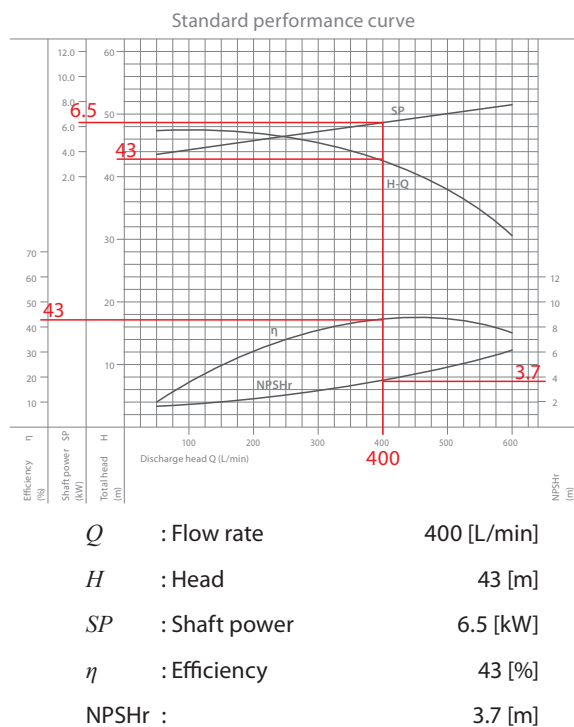
5.1 Select provisional model

Select a pump that satisfies the required conditions from a product catalog or from individual standard performance curves.

In this case, the following model is selected.

Provisional model:
MDM 40 - 1902 _ _ _ F _ _ - _ 2

Check the pump performance with the required specifications using the standard performance curves for the selected pump.



5.2 Review NPSH

$NPSHa = 5.67$ [m], $NPSHr = 3.7$ [m]

$$NPSHa > NPSHr + 0.5$$

The calculated $NPSHa$ and $NPSHr$ satisfy the above relationship

5.3 Calculate kinematic viscosity

$$\text{Kinematic viscosity: } \nu = \frac{\mu}{\rho} \times 1000$$

μ : Viscosity 26 [mPa·s] or [cP]
 ρ : Density 1840 [kg/m³] (Specific gravity $\times 10^3$)

Kinematic viscosity: $\nu = 14.1$ [cSt]

in this example, the fluid viscosity ν is greater than 4.3, so the power specification needs to be revised. Proceed to step 5.4.

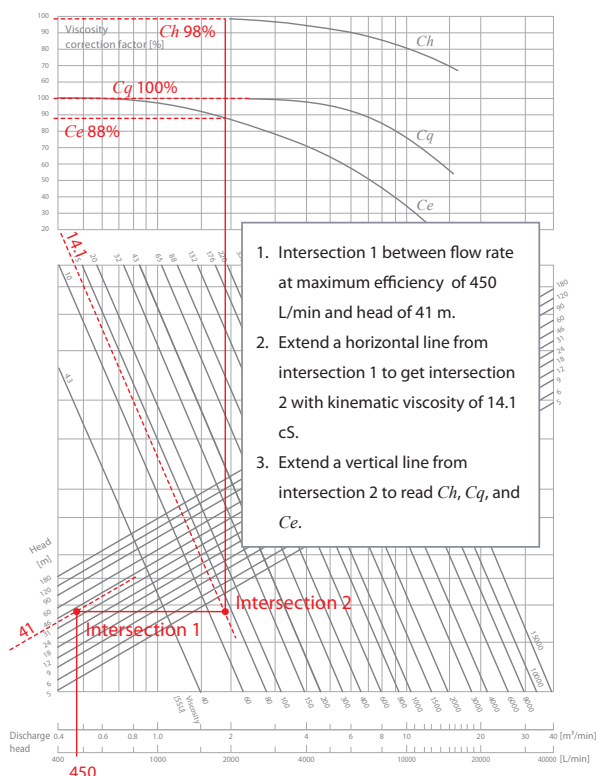
5.4 Correct performance

Refer to the flow rate and head at the point of maximum efficiency of the pump from the standard performance curves.

Maximum efficiency point

Flow rate: 450 L/min, Head: 41 m

Read the viscosity correction factor (head Ch , flow rate Cq , efficiency Ce) from the performance correction curve.



Calculate the corrected head, corrected flow rate, corrected efficiency, and corrected shaft power.

$$\begin{aligned}
 \text{Corrected head} &= \text{Head} : H_w \times C_h \\
 &= 43 \times 0.98 = 42.1 \text{ [m]} \\
 \text{Corrected flow rate} &= \text{Flow rate} : Q_w \times C_q \\
 &= 400 \times 1.00 = 400 \text{ [L/min]} \\
 \text{Corrected efficiency} &= \text{Efficiency} : E_w \times C_e \\
 &= 43 \times 0.88 = 37.8 \text{ [%]} \\
 \text{Corrected shaft power} \\
 &= \frac{0.163 \times \text{Specific gravity} \times \text{Corrected head [m]} \times \text{Corrected flow rate [L/min]}}{\text{Corrected efficiency [\%]} / 100} \times 10^{-3} \\
 &= 13.4 \text{ [kW]}
 \end{aligned}$$

5.5 Correct performance

Check whether the calculated corrected performance satisfies the required specifications.

Required specification

Flow rate: 400 L/min, Head: 37.8 m

Corrected performance

Flow rate: 400 L/min, Head: 42.1 m

You can now check to see if the required specifications are satisfied.

5.6 Review power

Review the size of motor that supplies the corrected shaft power. The shaft power of the pump should be larger than planned due to cover any changes in operating point, type of fluid, or other cause, hence a margin of at least 10% should be maintained for normal operation.

$$\text{Corrected shaft power: } SP = 13.4 \times 1.1 = 14.7 \text{ [kW]}$$

Therefore, the required motor size must deliver 14.7 kW or higher.

Select a pump with 15 kW rated output from the product lineup.

5.7 Select materials

Select the materials of wet ends for the handled fluid.

On the MDM pumps, the main wet-end plastic material that can be selected is CFRETFE (E type) or PFA (P type) depending on liquid properties. If corrosion is not a problem, CFRETFE (E type) is recommended for a cost advantage.

The following options are available for the bearing/spindle material.

Bearing/spindle material

CF type	Carbon/Alumina ceramics
KK type	SiC/SiC

The CF type combination is recommended for its dry-running capability. Therefore, the material symbol in the model name is E CF.

STEP 6

Pump Model Decision

Check the required flange connection standard and the requirements for pump drain and pump base before making a final decision on the pump model.

Selected model:

MDM 40 - 1902 E CF F 150 J - D 2

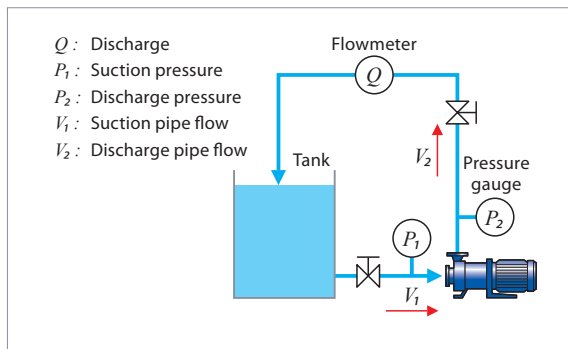
Topic How to determine NPSHr

How to calculate the NPSHr of a pump?

NPSHr is the minimum head (water head) required by a pump to prevent cavitation in the pump. Although there are several ways of measuring the NPSHr, including throttling the suction valve, reducing the pressure in the suction tank and increasing the liquid temperature, the principle behind any method is the same: reducing the suction head until cavitation occurs in the pump.

It is difficult to clearly determine the exact point where the cavitation occurs in the course of reducing the suction head. Today, it is generally considered that cavitation occurs when the pump shows a reduction in total head of 3%. The NPSHr value determined in this way, in particular, is sometimes called NPSH3.

Now, let us take the method of throttling a suction valve as an example to explain the testing procedure.



The figure above shows the outline of the NPSHr measuring system. First, start up the pump with the suction valve fully opened, and then adjust the discharge valve until the flow rate reaches a certain level. The total head measured at this point is used as a reference.

Refer to "Total head" of the glossary on page 74.

Where P_A is standard atmospheric pressure = 101325[Pa]; and P_V is saturated vapor pressure of room temperature water = 2339[Pa],

Total head in this condition can be calculated as follows:

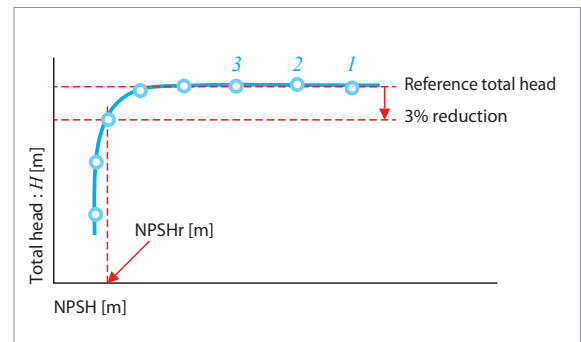
$$\text{NPSH} = 10.33 - 0.24 = 10.09 \text{ [m]}$$

Where H (total head) = 10.33 [m]; and NPSH = 0.24 [m]

It can be confirmed that 10.09 m of NPSH is already available at the tank level.

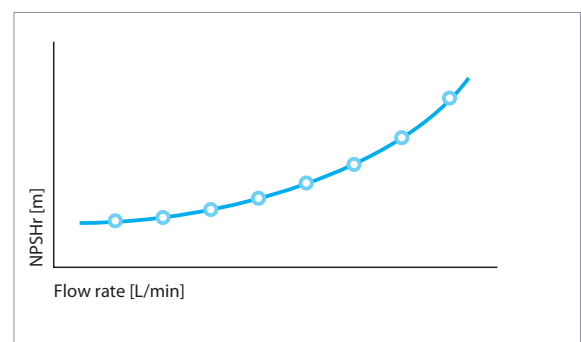
Next, throttle the suction valve slightly. Because P_1 is reduced due to pressure loss, NPSH is decreased. To compensate the reduction in flow rate, open the discharge valve a little bit to restore the flow rate to its original level.

By repeating the steps described above, calculate the total head for each case while gradually reducing the NPSH value. If all of the intersections of each total head and each NPSH value are plotted on the graph, a curve will appear as shown in the figure below.



Finally, the NPSHr value at this flow rate can be determined by locating the intersection of the minus 3% line from the reference total head and the NPSH curve.

Because the NPSHr of a pump varies with the flow rate, repeat the above testing procedure at various flow rates. Once all the calculated NPSHr values are plotted on the graph, the NPSHr characteristic curve can eventually be obtained.



Reference

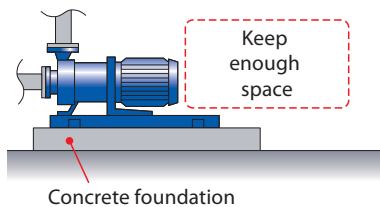
Piping design tips and guide

In order to safely use and maximize the performance of the pump, Please consider the following notes when planning piping, design and construction. In addition, please be sure to read the instruction manual when installing and using the pump.

Installation

Installation location

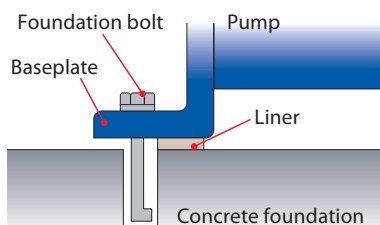
- Keep enough space around the pump for the back pull-out of motor, assembly and maintenance of the pump.



- Select a flat and sound foundation, free from vibration, for an installation location.
- The installation location should be free from exposure to water.
- Provide necessary equipment and a space for carrying the pump in and out.

Foundation work

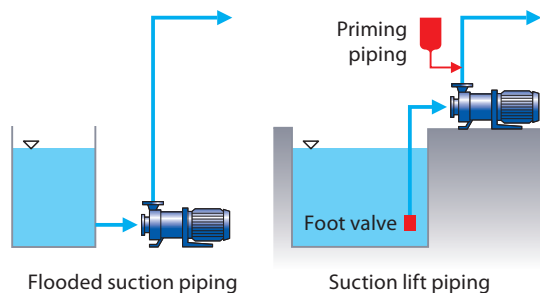
- Use a level to check if the foundation is flat. Securely fix the base by foundation bolts.
- Insert a shim if there is a gap between the base bottom and foundation surface.
- The foundation should be larger than a pump base footprint.
- See the diagram below as necessary.



Pipework

Flooded suction is recommended

- Install the pump as close to the tank as possible and at a lower position than the tank (flooded suction).
- If the pump is installed at the location that the pump suction port is at a higher position than the liquid level of tank (suction lift style), install the priming piping and foot valve.

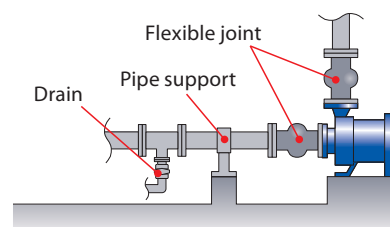


Pipe support

- Try not to apply a pipe weight to the pump inlet and outlet flanges.
- Install the pipe support so that the pump does not support the weight of the pipe.

Drain

If the liquid must be drained to protect from freezing, install a drain valve.



Piping for flushing

Install pump flushing piping if dangerous liquid will be handled.

Pipe connection

Pipes must be connected securely so that the air can not be introduced. If the sealing is not perfect, air is introduced causing pump damage.

Prevent water hammer

Refrain from the use of fast operating such as electromagnetic valves or automatic valves if possible.

Supply tank

Select an appropriate tank size

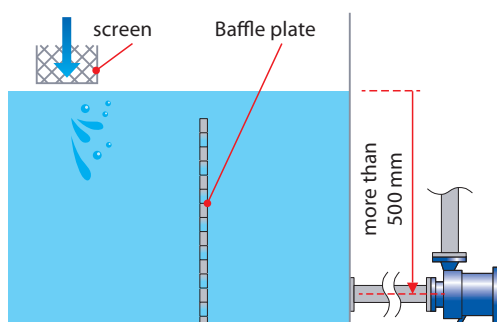
Using a high flow pump and small supply tank, the liquid level in the tank changes greatly.

End of suction piping

The end of suction pipe always should be located 500 mm or more below the liquid level. Take care so that air can not be introduced into suction piping.

End of suction line

Provide a screen in the supply tank to prevent foreign matter from entering the pump. (Clean the screen periodically.)



Suction line

Shortest piping

- Employ the fewer possible bends and the shortest possible piping length.
- Try to reduce the number of joints. If air enters the suction line, liquid may not be pumped or the pump may break and fail.

Pipe diameter

Pipe diameter should be larger than pump inlet bore. That flow velocity in the tube of 1.5 m/s or less is appropriate.

$$\text{Pipe diameter : } d = \sqrt{\frac{4 \times Q}{V \times \pi}}$$

d : Pipe diameter [m]
 Q : Capacity [m³/s]
 V : Flow velocity [m/s]

Straight piping

Employ straight pipe just before the pump inlet port.

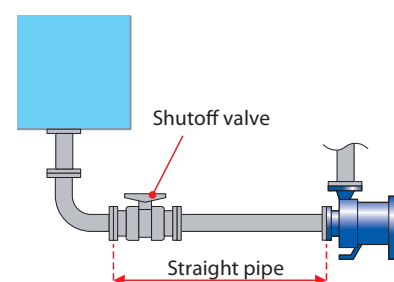
- Pump inlet bore 50A or smaller :

Straight pipe of 500 mm or longer

- Pump inlet bore 65A or larger :

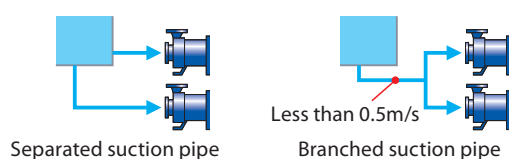
Straight pipe of 8 times as large as the inlet port

For the easy pump dismantling and maintenance, install a removable short length pipe of 300mm or so in the straight piping.



Separated suction pipe

Each pump requires suction piping directly from suction tank. If you use one suction of piping for several pumps, the flow speed at the collecting piping section must be less than 0.5 m/s.



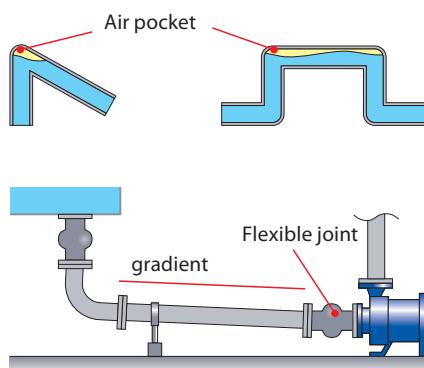
Install shutoff valves (gate valves)

Install shutoff valves (gate valves) for maintenance and inspection work.

Shutoff valves on suction pipes should be fully opened during operation.

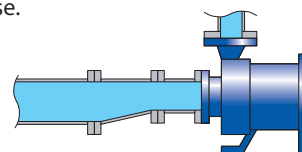
No air pocket in piping

- Do not allow any bend in piping where air may be trapped along the suction pipe.
- Do not make an notched line in order to prevent air from being trapped.
- Suction pipe should have an ascending gradient.



Different diameter of pipes

If diameter of pump suction port is different from that of suction pipe, use the eccentric reducer pipe. Connect the eccentric reducer pipe so that upper side is level. Residual air may not go out if it is mounted in reverse.



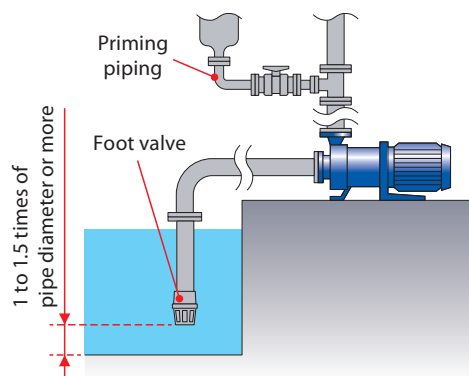
$NPSH_a > NPSH_r + 0.5 \text{ m}$

If suction is not good (e.g., the suction tank is a vacuum, the suction head is large, or the suction pipe is long), the condition $NPSH_a > NPSH_r + 0.5 \text{ m}$ should be established.

For the $NPSH_r$ level, refer to the standard performance curve.

In case of suction lift piping

- The end of suction piping should be 1 to 1.5 times of pipe diameter or more away from the bottom of suction tank.
- Install foot valve or check valve in suction piping.
- Periodical maintenance is required to prevent foot valve or check valve from clogging.
- Install piping for priming.



Discharge line

Pipe diameter

If the discharge piping is long, the specified performance may not be obtained because of unexpected pipe resistance particularly if the pipe diameter is the same as pump bore. Calculate the pipe resistance in advance to decide the proper diameter of pipe.

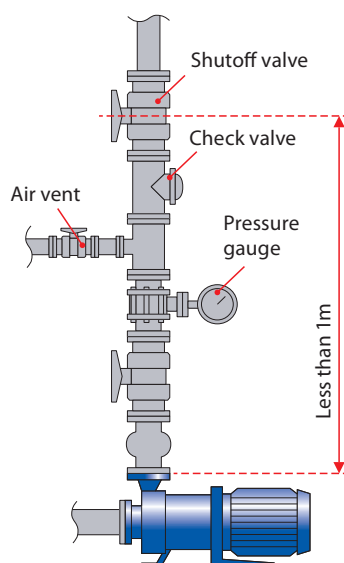
Install shutoff valves (gate valves)

Install shutoff valves (gate valves) for flow rate adjustment, operation start/stop, operation maintenance and inspection work.

It is recommend to keep 1 m distance between the pump discharge and the shutoff valve.

Pressure gauge installation

A pressure gauge is recommend to monitor an operating state.



Air vent

- Install an air vent line that branches between the pump and a check valve for degassing at start-up or maintenance as long as the check valve is installed the discharge line.
- If horizontal discharge piping is longer than 15 to 20 meters, install an air vent in that section of piping.

Check valve installation

Install a check valve in the following cases:

When selecting a check valve, check its maximum operating pressure to make sure it tolerates a possible pressure rise due to water hammer or backflow.

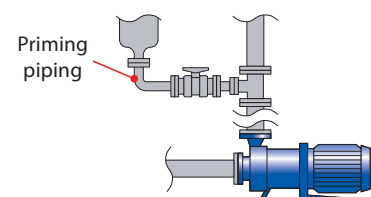
1. Discharge line is too long.
2. Actual delivery head (static discharge head plus discharge pipe resistance) is more than 15m.
3. The end of the discharge line is 9m higher than the liquid level in the tank.
4. Several pumps are running in parallel.

By-pass piping

When reducing flow, by-pass piping must be installed. (return to suction tank).

For suction lift piping

- Install piping for priming.



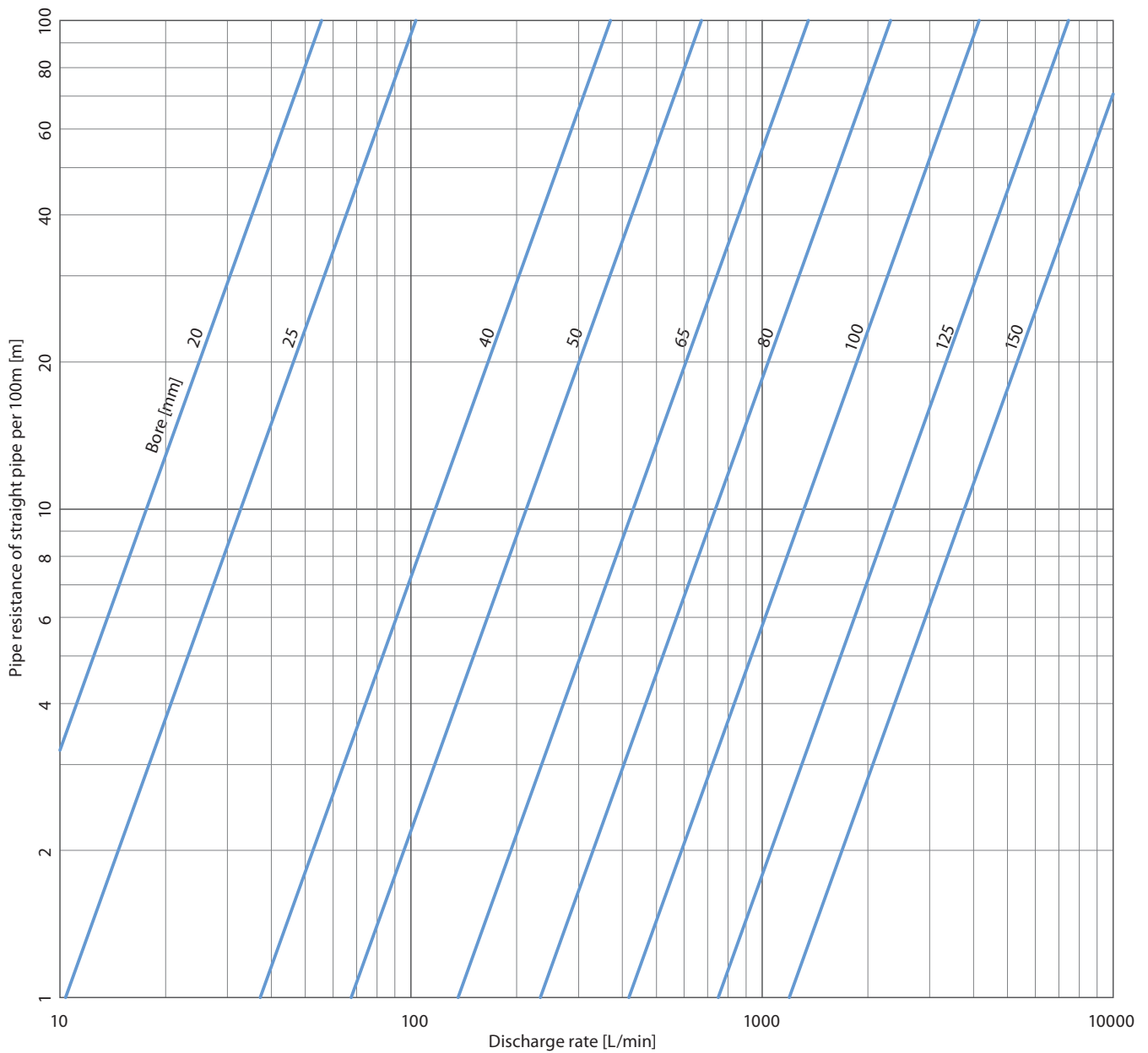
Equivalent straight pipe length of typical couplings

Equivalent straight pipe length [m]

Fittings	Connection	3/4" 20A	1" 25A	1 1/4" 32A	1 1/2" 40A	2" 50A	2 1/2" 65A	3" 80A	4" 100A	5" 125A	6" 150A	8" 200A
Elbows Regular 90°	Screwed	1.3	1.6	2.0	2.3	2.6	2.9	3.4	4.0			
	Flanged	0.4	0.5	0.6	0.7	0.9	1.1	1.3	1.8	2.2	2.7	3.7
Elbows Long radius 90°	Screwed	0.7	0.8	1.0	1.0	1.1	1.1	1.2	1.4			
	Flanged	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.3	1.5	1.7	2.1
Elbows Regular 45°	Screwed	0.3	0.4	0.5	0.7	0.8	1.0	1.2	1.7			
	Flanged	0.2	0.3	0.4	0.4	0.5	0.6	0.8	1.1	1.4	1.7	2.4
Tees Line flow	Screwed	0.7	1.0	1.4	1.7	2.4	2.8	3.7	5.0			
	Flanged	0.3	0.3	0.4	0.5	0.6	0.6	0.7	0.9	1.0	1.2	1.4
Tees Branch flow	Screwed	1.6	2.0	2.8	3.0	3.7	4.0	5.2	6.4			
	Flanged	0.8	1.0	1.3	1.6	2.0	2.3	2.9	3.7	4.6	5.5	7.3
Return bends 180°	Screwed	1.3	1.6	2.0	2.3	2.6	2.8	3.4	4.0			
	Flanged	0.4	0.5	0.6	0.7	0.9	1.1	1.3	1.8	2.2	2.7	3.8
Globe valve	Screwed	7.3	8.8	11.3	12.8	16.5	18.9	24.1	33.5			
	Flanged	12.2	13.7	16.5	18.0	21.3	23.5	28.6	36.5	45.6	57.8	79.1
Gate valve	Screwed	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.8			
	Flanged					0.8	0.8	0.9	0.9	1.0	1.0	1.0
Angle valve	Screwed	4.6	5.2	5.5	5.5	5.5	5.5	5.5	5.5			
	Flanged	4.6	5.2	5.5	5.5	6.4	6.7	8.5	11.6	15.2	19.2	27.4
Swing check valve	Screwed	2.7	3.4	4.0	4.6	5.8	6.7	8.2	11.6			
	Flanged	1.6	2.2	3.1	3.7	5.2	6.4	8.2	11.6	15.2	19.2	27.4
Diaphragm valve	Flanged	1.1	1.7		3.2	3.9	5.0	8.3	11.0	9.6	9.5	24.7
Butterfly valve	Flanged				1.2	0.8	1.1	2.8	4.3	4.8	7.1	6.3
Union joint	Screwed	0.07	0.09	0.1	0.1	0.1	0.1	0.1	0.2			
Bell mouth piping		0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7
Flat piping		0.4	0.6	0.8	0.9	1.3	1.6	2.0	2.9	4.0	4.9	7.0
Insert piping		0.80	1.1	1.5	1.9	2.6	3.0	4.0	4.8	7.6	9.7	13.7

note: The above data is for reference only.

Quick reference chart for pipe resistance



note: The above data is for reference only.

Chemicals requiring caution

The following information is provided based on experience gained by IWAKI.

Some details may change depending on the nature of the fluid and the pump operating conditions.

For information relating to the handling of various chemicals, refer to the MSDS issued by the manufacturer of the chemical.

High-viscosity fluids

Sodium hydroxide, sulfuric acid, etc.

- Viscosity limit :

The pump head and flow rate reduce as the viscosity of the fluid increases, accompanied by a reduction in pumping efficiency. In addition, the amount of internal circulation within the pump itself tends to decrease. Consequently, the pumping of extremely high viscosity fluids may cause overheating of the bearings and potentially a risk of poor lubrication.

To counter this problem, Iwaki imposes a limit on viscosity of 120 mPa·s on fluids in magnetic drive pumps. Please contact IWAKI for more information about the handling of higher viscosity fluids.

- Precautions against fluid temperature drop :

In general, the viscosity of a fluid increases as the temperature drops. The fluid viscosity increases as the temperature of the fluid drops after stopping pumping and as the ambient temperature drops. This may result in a higher required shaft power than originally planned when pumping resumes, and the required flow rate may not be achievable.

Accordingly, a sufficient motor power margin should be maintained to cover this scenario.

A normal motor power margin of 10% is recommended. However, if there is an expectation of the kind of viscosity problem mentioned above, it is recommended that a margin greater than 10% be maintained.

- Precautions for air venting operation :

During operation, you can release any air trapped in

the pipes and inside the pump using a relief valve.

However, separation of fluid and gas is more difficult in high-viscosity fluids, compared to water, meaning that some residual air may be left the pump after relieving. In such cases, venting of air must be conducted more frequently.

Specifically, increasing the number of inching motions and the flow rate are effective.

If the planned flow rate is relatively low, the flow rate will tend to drop even further when venting air, so maintaining a sufficient motor power margin and venting at as high a flow rate as possible is recommended for the effective release of trapped air.

Fluids with high electrical-insulating properties

Ultra-pure water, inert fluids, etc.

Fluoroplastics used for wet ends in the pump have high insulation properties. When handling fluids with high-insulation properties, friction between the fluid and fluorocarbon polymer materials can cause a build-up of static electricity within the pump.

If an excessive electrostatic charge accumulates, an electrical discharge (spark) may occur within the pump that can damage components. Accordingly, anti-static measures are recommended.

Note that models for handling ultra-pure water are also available by custom order. For more information, contact IWAKI.

Fluids containing slurry

Silica, iron powder, etc.

As a rule of thumb, the maximum limits on slurry permitted in a magnetic pump are 5 wt% density, 50 μm particle size, and 80 Hs hardness. However, magnetic pumps are basically unsuitable for the handling of fluids that contain slurry.

Slurry not only leads to increased wear of pump components, but can also accumulate in the clearances of the bearing and spindle, potentially causing poor lubrication.

In addition, the pump may become damaged, depending on the properties of the slurry and the operating conditions. Testing under actual conditions are essential.

Observe the following points if pumping fluid containing slurry.

- Select SiC material for bearings

SiC (KK type) is a very hard material that prevents wear of the bearings. Carbon (CF type) wears more easily, compared to SiC, and its use should be avoided.

- Prevent slurry in the supply tank

Damage to the pump can be greatly reduced by preventing slurry in the supply tank. The risk of slurry deposits entering the pump is further reduced by placing the suction pipe inlet some distance off the bottom of the supply tank.

If possible, however, avoid placing a filter in the suction pipe. A clogged filter can cause cavitation and other trouble in the pump.

Foaming fluids

Hydrogen peroxide, sodium hypochlorite, etc.

If the amount of gas bubbles created during pumping is relatively small, any affect on pump performance may safely be ignored. However, if a large volume of gas bubbles enters the pump, not only will there be a drop in pump performance, but there is also a risk that it may lead to poor lubrication of the bearing.

In addition, any air bubbles generated may accumulate in the suction pipe when the pump stops and that air may flow into the pump all at once when the pump is restarted, potentially causing a vapor lock condition.

Accordingly, air venting is required each time before starting the pump when handling fluids that contain or generate large quantities of gas bubbles. Adding a gas relief pipe on the discharge side is required and adding a gradient to the suction pipe to help release trapped gas is also effective.

Fluids that crystallize easily

High salt concentration, etc.

In handling fluids prone to crystallization, management of liquid temperature and concentration will be required to ensure the fluid is not in an oversaturated state. Any crystal material generated from a fluid in an oversaturated state may adhere to and accumulate in the clearances of the pump wet ends, leading to the pump sticking or seizing.

Fluids with high permeability

**Nitric acid, hydrofluoric acid,
Halogenized hydrocarbon solvents, etc.**

Fluoroplastics used in process magnetic pumps have a very high corrosion resistance compared to metallic materials. On the other hand, plastics are also materials where the permeation of chemicals is inevitable.

In particular, when handling nitric acid, hydrofluoric acid, hydrocarbon solvents, and other fluids with a high permeability at high temperatures, the effects of permeability must be considered.

The following typical effects of permeability may occur:

- Corrosion of metallic components due to chemical permeation
- Blistering of plastic due to chemical permeation

In both cases, pump trouble will not occur in the short term, but will manifest itself gradually, depending on the duration and conditions of use.

If handling chemicals with high permeability, inspect the interior of the pump regularly (every 3 to 6 months) in order to determine the condition of pump component.

Halogenated chemicals

Halogenated hydrocarbon chemicals are chemicals with high permeability and at the same time are corrosive to fluorocarbon polymers at high temperatures. In addition, hydrocarbon-based chemicals have a high saturated vapor pressure, making the pumping of such fluids highly susceptible to cavitation. Therefore, pump liquid ends made from plastics are not suitable.

Fluids containing corrosive gases

Free chlorine, ozone, etc.

Magnetic pumps are designed for pumping fluids, and are unsuitable for pumping fluids containing large volumes of gas. In particular, the handling of fluids containing corrosive gases can adversely affect the pump.

For example, the circulation of sulfuric acid in chlorine gas drying towers and other fluids that produce chlorine gas pose a corrosion risk to carbon materials. Always select SIC (KK type) material for bearings.

Fluids that attack fluorocarbon polymers

Fluorocarbon polymer materials have excellent chemical resistance in general, but there are some exceptions (below) that do attack fluorocarbon polymers.

If the wet end material is PFA :

- High-concentration hydrofluoric acid (HF) at more than 100°C
- Strong oxidizing agents at high temperature such as Chlorine trifluoride (ClF₃), bromine trifluoride (BrF₃), iodine pentafluoride (IF₅)

If the wet end material is ETFE :

- Chemicals above that cannot be handled with PFA
- Halogenated organic compounds such as Chloroform (CHCl₃), Perchloroethylene (C₂Cl₄)

Low-temperature fluids

Antifreeze, etc.

If handling low-temperature fluids such as antifreeze, precautions are required to guard against the formation of condensation and frost. In particular, any frost that adheres to the rear casing may come into contact with and damage the drive magnet.

Covering the surface of the pump with thermal insulation material and reducing the temperature difference with outside air are effective.

Plating solutions

Gold plating, chrome plating, etc.

In so-called water gilding, a electric potential difference is applied to a product in a plating bath to create a surface film, but here it refers to components of plating solutions deposited on the inside of the pump.

As the deposits increase, friction loss of sliding components increases and may eventually lead bearings seizing. The level of deposit formation depends on the type, temperature, and concentration of the plating solution, so evaluation of the working life of the pump based on past history and actual operation is required when selecting a pump.

In electroless nickel plating, more deposits in the pump can also be expected. For more information, contact IWAKI.

Specific gravity/viscosity of major liquids

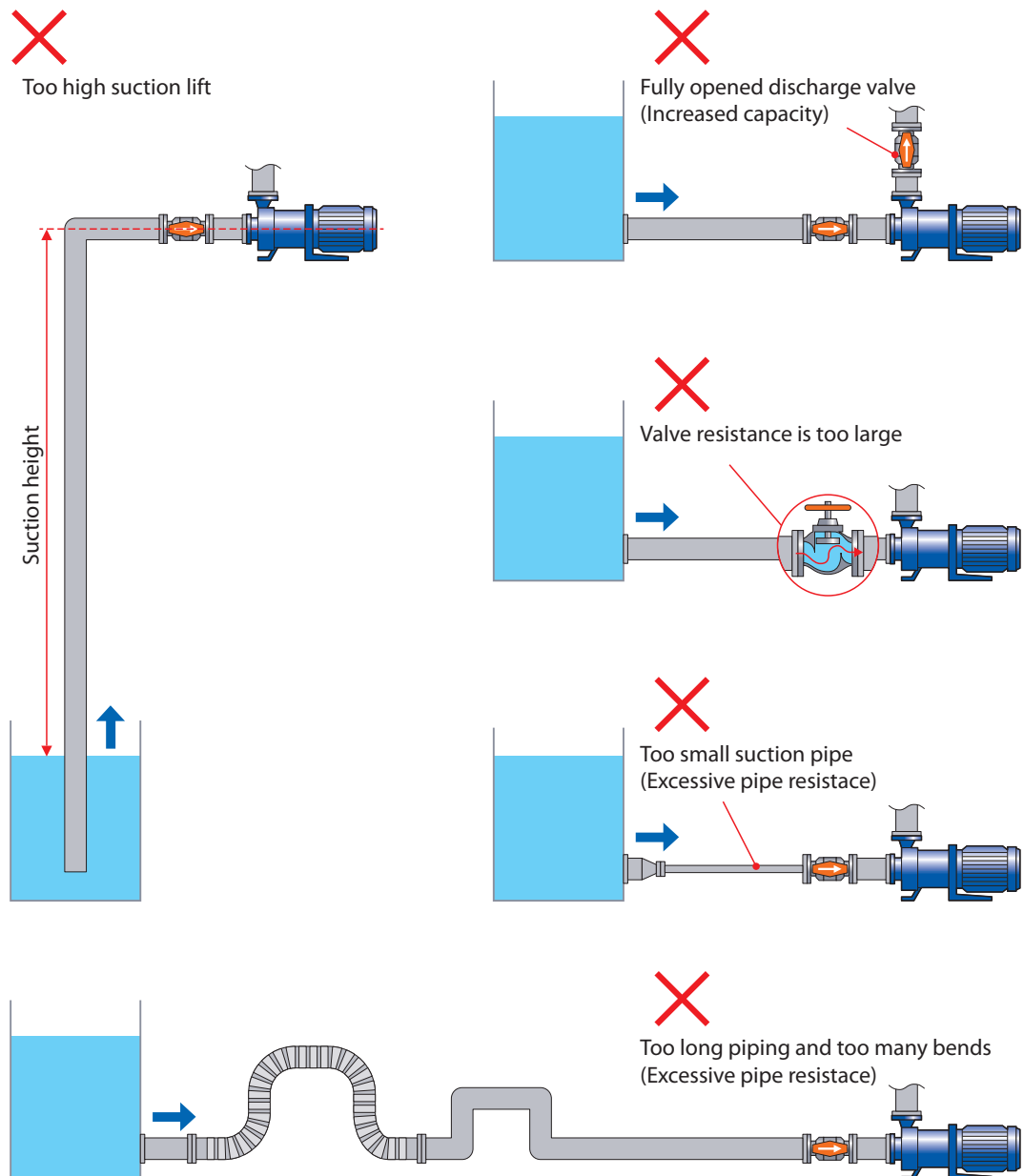
Chemical	Concentration [%]	Specific gravity	Viscosity [mPa·s]												
			Temperature [°C]												
			-20	-10	0	10	20	30	40	50	60	70	80	90	100
Water H ₂ O	-	1.00			1.79	1.31	1.00	0.80	0.65	0.55	0.47	0.40	0.36	0.32	0.28
Ethylene glycol HOCH ₂ .CH ₂ OH	20	1.03			3.05	2.29	1.70	1.28	1.00	0.82	0.70	0.60	0.50	0.44	
	40	1.06	17.00	9.76	5.81	3.79	2.78	2.20	1.78	1.40	1.08	0.88	0.79	0.67	
	60	1.09	26.00	16.91	11.00	7.28	4.99	3.59	2.72	2.14	1.74	1.44	1.20	0.98	
	80	1.11	79.98	42.12	22.63	13.48	9.38	7.18	5.43	3.77	2.49	1.95	2.08	1.88	
	100	1.12			55.00	33.58	21.00	13.75	9.49	6.82	5.02	3.81	3.06	2.57	
Calcium chloride CaCl ₂	10	1.08			2.17	1.58	1.27								
	20	1.18			3.14	2.32	1.89								
	30	1.28			5.80	4.40	3.60								
	40	1.39													
Sodium chloride NaCl	10	1.07			2.01	1.51	1.19	0.95	0.78	0.67	0.57	0.51	0.45		
	20	1.15			2.67	1.99	1.56	1.24	1.03	0.87	0.74	0.64	0.57		
	25	1.19			3.31	2.38	1.88								
Hydrochloric acid HCl	10	1.05		2.58	1.94	1.50	1.19		0.79		0.56		0.41		0.31
	20	1.11		2.73	2.13	1.71	1.39		0.98		0.72		0.56		0.45
	30	1.15		3.21	2.54	2.07	1.73		1.27		1.00		0.82		
	36	1.18		3.74	2.98	2.44	2.04		1.51						
Caustic potash KOH	10	1.11					1.23	1.00	0.83	0.71	0.61	0.53	0.47	0.42	0.38
	20	1.22					1.63	1.33	1.11	0.94	0.82	0.72	0.63	0.57	0.51
	30	1.29					2.36	1.93	1.57	1.40	1.20	1.00	0.88	0.78	0.70
	40	1.40					4.10	3.20	2.50	2.10	1.80	1.50	1.30	1.20	1.00
	50	1.53					8.70	6.30	4.80	3.80	3.10	2.50	2.20	1.90	1.60
Sodium hydroxide NaOH	10	1.11					1.86	1.43	1.14	0.93	0.78	0.66	0.55	0.47	0.40
	20	1.22					4.43	3.17	2.43	1.93	1.57	1.26	1.03	0.84	0.68
	30	1.33					12.60	8.43	5.99	4.38	3.28	2.55	2.02	1.62	1.28
	40	1.43					38.10	21.80	13.50	9.00	6.36	4.76	3.69	2.89	2.29
	50	1.53					120.00	44.70	25.50	15.80	10.40	7.60	5.60	4.36	3.41
Acetic acid CH ₃ COOH	10	1.01					1.21	0.96	0.75	0.65	0.55				
	20	1.02					1.42	1.11	0.91	0.75	0.63				
	30	1.04					1.64	1.29	1.04	0.86	0.71				
	40	1.05					1.88	1.48	1.18	0.97	0.80				
	50	1.05					2.14	1.66	1.33	1.08	0.90				
Nitric acid HNO ₃	20	1.11				1.32	1.05	0.86	0.71						
	40	1.24				1.60	1.30	1.08	0.91						
	60	1.37				2.62	2.00	1.63	1.36						
	80	1.44				2.37	1.88	1.54	1.26						
	100	1.50				1.04	0.89	0.77	0.68						
Hydrofluoric acid HF	10	1.04			1.68										
	20	1.08			1.57										
	30	1.12			1.46										
	40	1.16			1.34										
	50	1.20			1.21										
	100	1.00			0.41										
Sulfuric acid H ₂ SO ₄	20	1.14		3.82	2.71	2.01	1.55	1.23	0.99	0.83	0.71	0.64	0.58		
	40	1.30	9.90	6.60	4.70	3.48	2.70	2.16	1.80	1.53	1.31	1.15	1.09		
	60	1.49			10.00	7.50	5.70	4.58	3.71	3.20	2.80	2.48	2.21		
	70	1.62			20.00	14.00	10.20	7.70	6.10	5.10	4.40	3.70	3.20		
	80	1.72			43.00	31.00	22.00	15.40	10.90	8.10	6.20	5.10	4.50		
	98	1.84				39.00	26.80	19.00	14.00	10.40	8.00	6.40	5.50		
Phosphoric acid H ₃ PO ₄	20	1.11					5.50	4.00	2.80		1.80		1.25		
	40	1.25					16.00	10.00	7.00		4.30				
	60	1.40					22.50	14.00	9.00		6.00				
	65	1.47					75.00	48.00	30.00		17.00		9.30		
	85	1.69													

The above data is for reference only.

Remedies when NPSHa is insufficient

Causes of shortage of NPSHa value	Countermeasure
Too low flooded suction height (h_s) Too high suction lift height	Lower liquid level of tank Lower pump installed level
Too large suction pipe resistance (h_{fs})	Use larger, shorter & straight piping Change to pipe or valve of smaller resistance
Too low pressure (P_a) on liquid surface of suction tank	In case of closed tank, pressurize with N2 gas etc. In case of vacuum tank, lower vacuum level
Too high vapor pressure (P_v)	Lower liquid temp. at pump inlet to reduce vapor pressure

It may be possible to select the pump which has lower NPSHr value by selecting, for example, the pump model one step larger.



Performance correction curve

1. To obtain coefficient of kinematic viscosity cSt of pumped liquid.

2. From the performance correction diagram, obtain respective corrected coefficient of head (Ch), discharge capacity (Cq), efficiency (Ce) at the most efficient point of the pump.

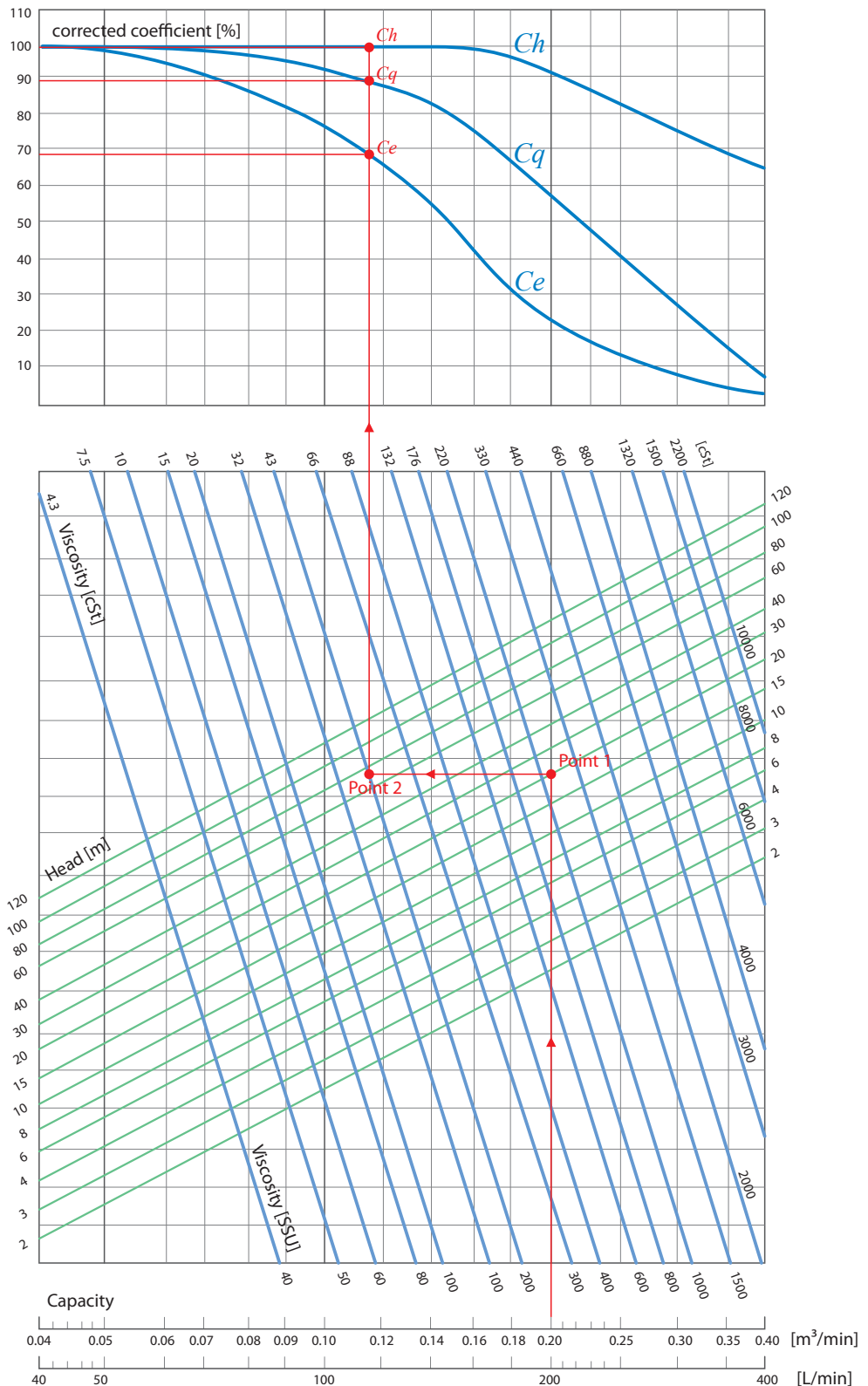
2-1. Get the intersection point 1 of the line extended vertically from the capacity at the most efficient point and the line of the head relative to the capacity.

2-2. Horizontally extend the line from the point 1 to get the intersection point 2 with the line of already got coefficient of kinetic viscosity cSt .

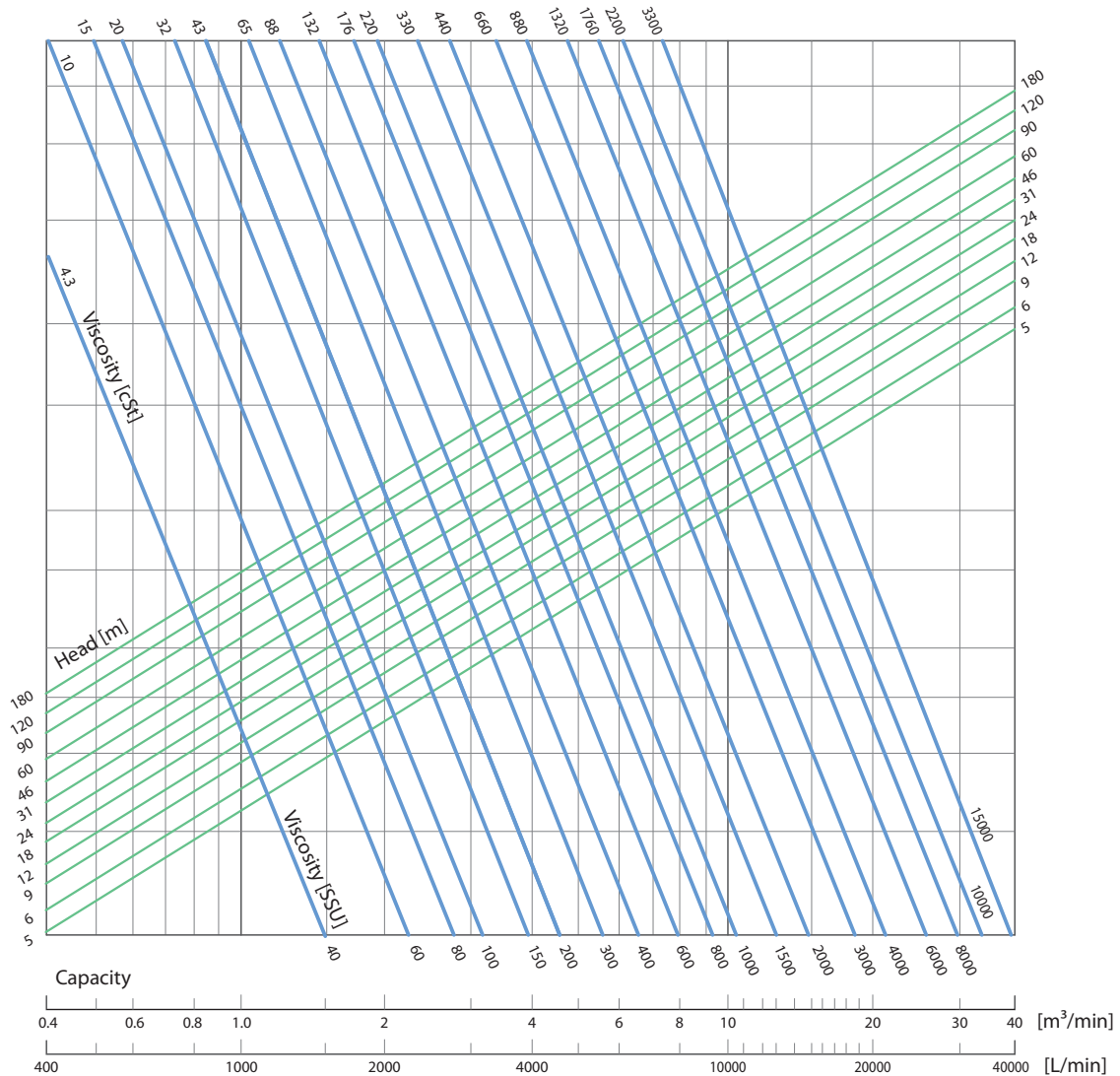
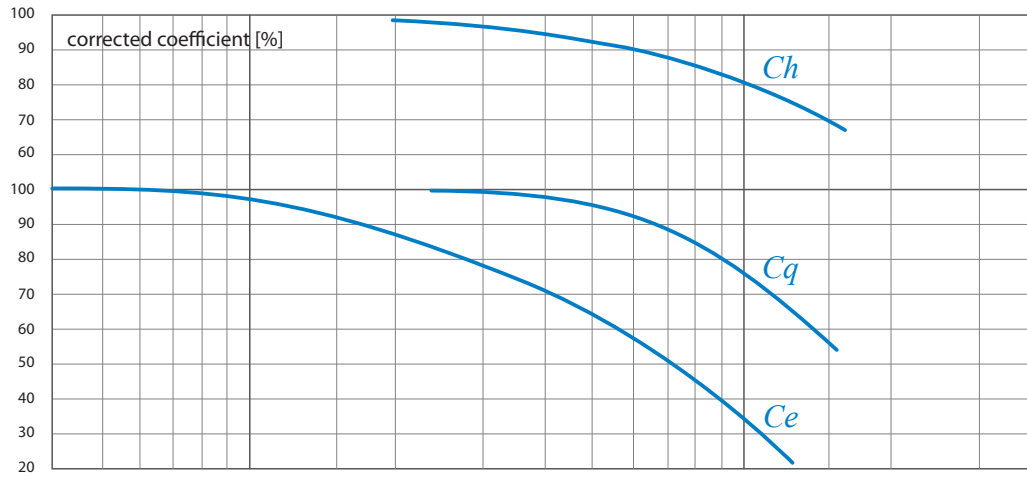
2-3. Vertically extend the line from the point 2 to get the respective intersection point with line Ch (head), Cq (capacity), Ce (efficient) to get the respective corrected coefficient (%).

3. Corrected head, corrected discharge capacity and corrected efficiency are obtained from following calculation, where H_w , Q_w and E_w are obtained from standard performance curves when pumping water, and Ch , Cq and Ce are the coefficient obtained from the calculation on above item 2.

Less than 400 L/min



More than 400 L/min



Pump startup procedure

Always check the following items before starting the pump. Also, be sure to read the instruction manual.

- | | | |
|--|--|--|
| ☐ Pipe layout | ☐ Sufficient level in the supply tank | ☐ Check discharge pressure at pump operating point |
| ☐ Pump power turned off | ☐ No foreign objects in the pipes | ☐ No possibility that other personnel will operate the pump |

STEP 1 Fill the pump with fluid

Check 1 Check pump for problems

Turn motor fan by hand

Heavy or does not turn

Turns freely

Assembly problem?

Pump failure?

Pump disassembly/
inspection

- Jammed by foreign objects
- Bearing damage
- Spindle damage
- Impeller damage
- Drive magnet contact

Fully open suction valve (OPEN)

Fully open discharge valve (OPEN)

Prime pump with fluid

If there is an air vent line, open the valve to release the air from the pipe

Turn motor fan by hand

If using a coupling connection type motor, remove the coupling cover and turn the coupling by hand

STEP 2 Bleed air from pipes

Check 2 Check motor rotating direction

Run pump for an instant (<0.5s)

Pump stops suddenly or emits strange noise

ADVICE
Correct direction of rotation is clockwise when viewed from the motor.

Reverse rotation

Motor wire connection error?

Check connections &
go to STEP 1

Correct direction, stops smoothly

If there is an air vent line:
Fully close discharge valve (CLOSE), fully open air vent valve (OPEN)

If there is no air vent line:
Leave discharge valve fully open

ADVICE
if air vent line is too narrow to release air and maintain sufficient flow rate, we recommend opening the discharge valve partway.

Repeat at least 10 times

Run pump for an instant (<1s)

Stops smoothly

ADVICE
We recommend you operate the pump for only 0.5s the first time, and then gradually increase to about 1s.

To STEP 3

Pump stops suddenly, or emits strange noise

STEP 3 Start the pump

Open the discharge valve halfway

ADVICE

Open the discharge valve just enough to maintain the minimum flow rate.
Running the pump with the valve closed may damage the pump

Start the pump

Check 3 Check that discharge pressure is not too low

Abnormal

Normal

Operate valve slowly to adjust the pressure

Check 4 Check that discharge pressure is at the specified pressure

Abnormal

Normal

- Forget to open valve?
- Magnetic coupling decoupling?
- Air entering operation?
- Motor rotating in reverse direction?
- Excessive flow rate?

Recheck condition of pipes

- Discharge into bypass tube
- Air pockets in pipes
- Air entering in

Check current consumption

- Higher than rated motor current
→ Excessive flow rate?
- Lower than rated motor current
→ Decoupling of magnet coupling

ADVICE

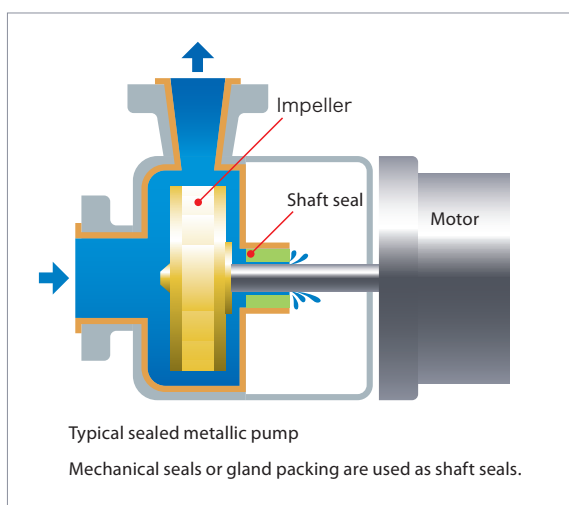
Measure the current consumption to accurately gauge the running status.

Normal operation

Stopping the pump

- Slowly close the discharge valve and turn off the motor power supply.
- Monitor the motor fan and check the motor stops smoothly.

When the different costs associated with the use of low corrosion-resistant materials and required maintenance are taken into account, conversion from conventional sealed metallic pumps to plastic lined magnetic drive pumps offers many advantages.



Fluoroplastics used in IWAKI's magnetic drive pumps have excellent corrosion resistance to both acid and alkaline liquids. In particular, magnetic drive pumps are best at the pumping of inorganic chemicals such as hydrochloric acid and sulfuric acid.

Generally, fluoroplastics have better corrosion resistance than so-called anticorrosion alloys such as hastelloy and nickel. Thus, the fluoroplastic parts will help reduce the costs associated with periodic parts replacement.

In addition, magnetic drive pumps without shaft seals will eliminate the possibility of leaks to the outside, reducing the burden on the surrounding environment.

There are several points to keep in mind when converting from sealed metallic pumps to plastic magnetic drive pumps.

First, you need to review the operating procedure and piping conditions for magnetic drive pumps.

Sometimes sealed metallic pumps are handled more roughly than magnetic drive pumps.

Some piping layouts may be prone to water hammer or air stagnation problems.

Even if the piping layout designed for a sealed metallic pump has not caused any problems yet, in some instances, the same layout can result in problems once the sealed metallic pump is replaced with a magnetic drive pump.

Secondly, you should also check the chemical specifications. Fluoroplastics used in magnetic drive pumps have good corrosion resistance; however, some chemicals may affect the useful life of components because of gas permeation occurring through the surface. Therefore, when handling highly permeable fluids or any high-temperature halogen based hydrocarbon solution, you should periodically inspect the internal pump surfaces.

These guidelines describe the preferred piping conditions, operating procedure and chemical specifications for magnetic drive pumps. Please read them carefully and consider the reasons to consider converting to magnetic drive pumps.

Advantages of converting to plastic lined magnetic drive pumps

- Excellent corrosion resistance to acid and alkaline
- Long useful life of components: reduced replacement costs
- No shaft seals costs
- Reduced maintenance costs
- Reduced downtime
- No leaks from seals

Points to keep in mind when converting to plastic lined magnetic drive pumps

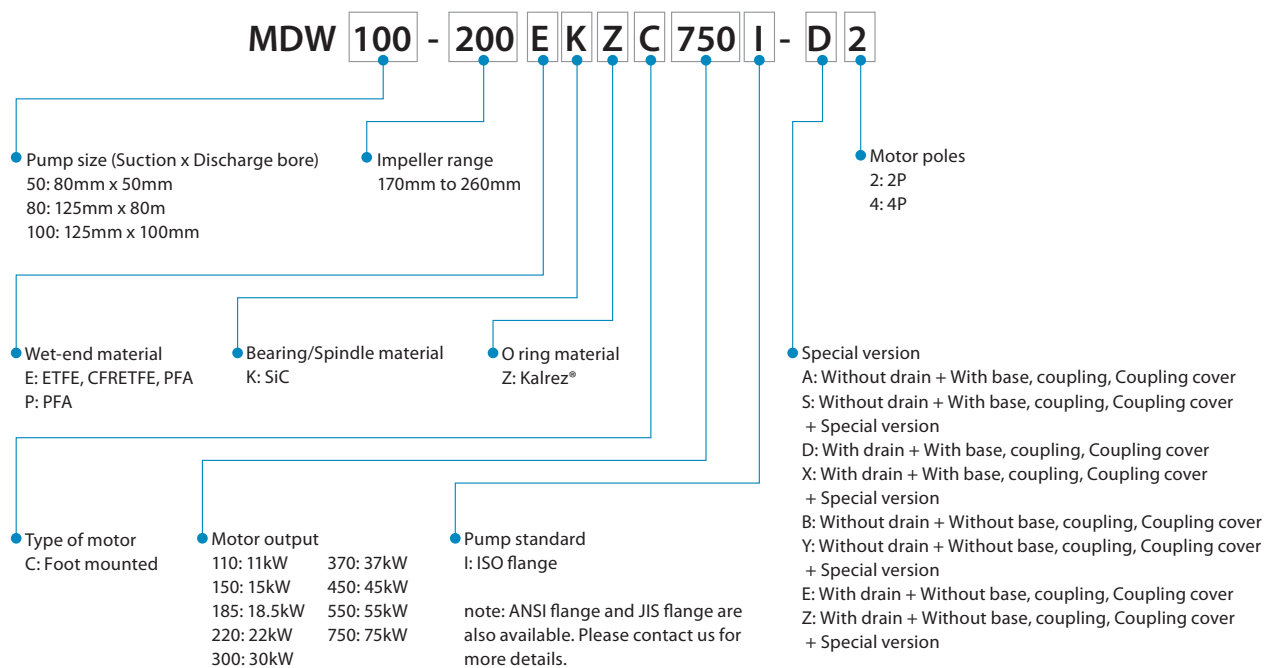
- Pump capacity/Mounting dimensions
- Review of the operating procedure and piping conditions
- Checking of chemical specifications

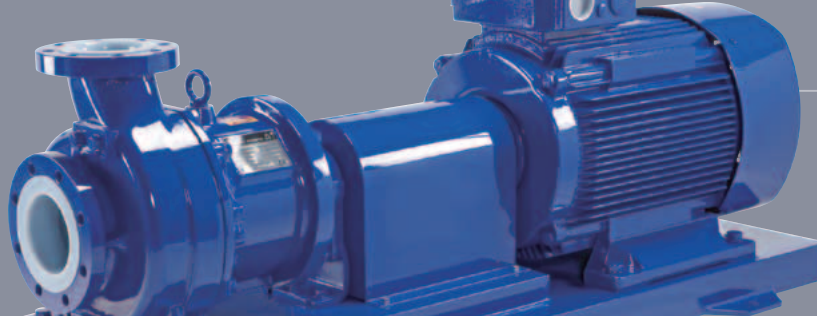
Product Specification

Specification (50/60Hz)

Model		MDW50	MDW80	MDW100
Discharge bore	mm	50	80	100
Suction bore	mm	80	125	125
Max. discharge head	m	2P	93/96	98/100
		4P	22/32	25/35
Max. discharge capacity	L/min	2P	1500/1500	4000/4000
		4P	800/800	2500/2500
Minimum flow	L/min	2P	200/200	1000/1000
		4P	200/200	200/200
Motor output	kW	2P	22, 30, 37, 45, 55, 75	37, 45, 55, 75
		4P	11, 15, 18.5, 22, 30, 37	11, 15, 18.5, 22, 30, 37
Max. operating pressure	MPa	1.6		
Viscosity limit	mPa·s	Less than 120 (Please contact us if the viscosity is more than 120)		
Allowable slurry		Hardness 80Hs or less, Particle size 50µm or less, Concentration 5wt% or less (Please contact us for more details)		
Liquid temp. range	°C	-10 to 120		-10 to 105
Installation		Ambient temperature 0 to 40 °C, Ambient humidity 35 to 85 %RH		
Mass (pump section)	kg	155	170	
Wet-end materials	Front casing	PFA	ETFE	
	Impeller	PFA	CFRETFE	
	Rear casing	PFA		
	Split plate	PFA		
	Magnet capsule	PFA		
	Bearing	SiC		
	Sleeve	SiC		
	Gasket	PTFE		
	O ring	Kalrez®		

Identification





Consumable parts

"Consumable parts" are defined as parts that should be replaced when pump is reassembled.

Parts name	Identification	Materials	Qty	Remarks
Gasket		PTFE	1	for Front casing
Gasket		PTFE	1	for Rear casing
Drain gasket		PTFE	1	
Air vent gasket		PTFE	1	
O ring	Z	Kalrez®	1	
O ring	Z	Kalrez®	1	

Spare parts

"Spare parts" are defined as parts that should be replaced periodic maintenance.

IWAKI recommends that the end-user keep the following parts on hand.

Parts name	Identification	Materials	Qty	Remarks
Bearing		SiC	1	
Impeller thrust		SiC	1	
Ball bearing			2	
Split plate assembly		PFA, Ductile cast iron, SiC	1	Split plate, Bearing, Thrust
Sleeve		SiC	1	
Oil seal		NBR	1	Replace it along with the ball bearing
Magnet capsule assembly		Magnet, PFA, SiC	1	

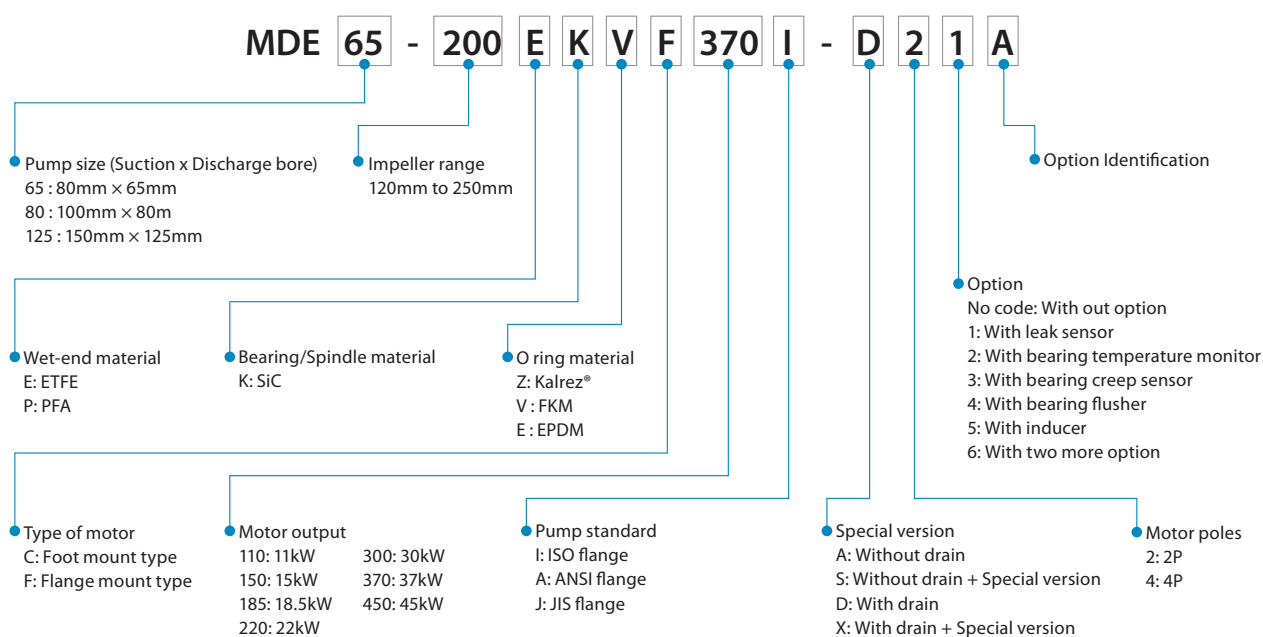
Please contact us for more details.

Specification (50/60Hz)

Model		MDE65-200 (2P)	MDE80-160 (2P)	MDE125-250 (4P)
Discharge bore	mm	65	80	125
Suction bore	mm	80	100	150
Discharge head	m	53.0/75.0	38.0/53.5	22.5/32.0
Discharge capacity	L/min	833/1000	1670/2000	2400/2900
Minimum flow	L/min	50	50	200

Model		MDE65	MDE80	MDE125
Impeller range	mm	170 to 210	120 to 160	190 to 250
Motor output	kW	2P	18.5, 22, 30, 37, 45	18.5, 22, 30, 37, 45
		4P	-	-
Max. operating pressure	MPa	1.6		1.0
Viscosity limit	mPa·s	Less than 120 (Please contact us if the viscosity is more than 120)		
Allowable slurry		Hardness 80Hs or less, Particle size 50μm or less, Concentration 5wt% or less (Please contact us for more details)		
Liquid temp. range	°C	0 to 100		
Installation		Ambient temperature 0 to 40 °C, Ambient humidity 35 to 85 %RH		
Standard motor		200/220V, 50/60Hz, 2Pole(4Pole), 3-phase, out door flange mount type		
Wet-end materials	Front casing	ETFE		
	Impeller	CFRETFE		
	Rear casing	PFA		
	Split plate	PFA		
	Magnet capsule	PFA		
	Bearing	SiC		
	Sleeve	SiC		
	Gasket	PTFE		
	O ring	Kalrez® /FKM/EPDM		

Identification





Consumable parts

"Consumable parts" are defined as parts that should be replaced when pump is reassembled.

Parts name	Identification	Materials	Qty	Remarks
Gasket		PTFE	1	for Front casing
Gasket		PTFE	1	for Drain
Gasket		PTFE	1	for Rear casing
O ring	Z V E	Kalrez® FKM EPDM	1	
O ring	Z V E	Kalrez® FKM EPDM	1	

Spare parts

"Spare parts" are defined as parts that should be replaced periodic maintenance.

IWAKI recommends that the end-user keep the following parts on hand.

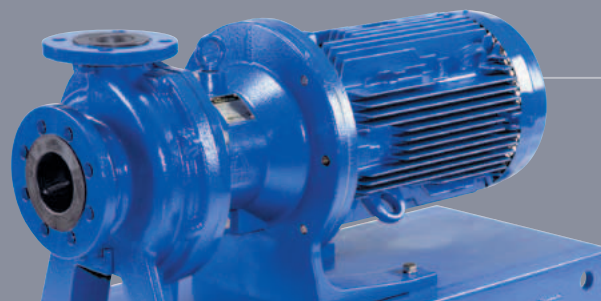
Parts name	Identification	Materials	Qty	Remarks
Impeller thrust		SiC	1	
Bearing		SiC	1	
Split plate assembly			1	Split plate, Bearing, Impeller thrust
Sleeve		SiC	1	
Magnet capsule assembly			1	Magnet capsule, Sleeve, Thrust Can not be disassemble the thrust and the magnet capsule

Please contact us for more details.

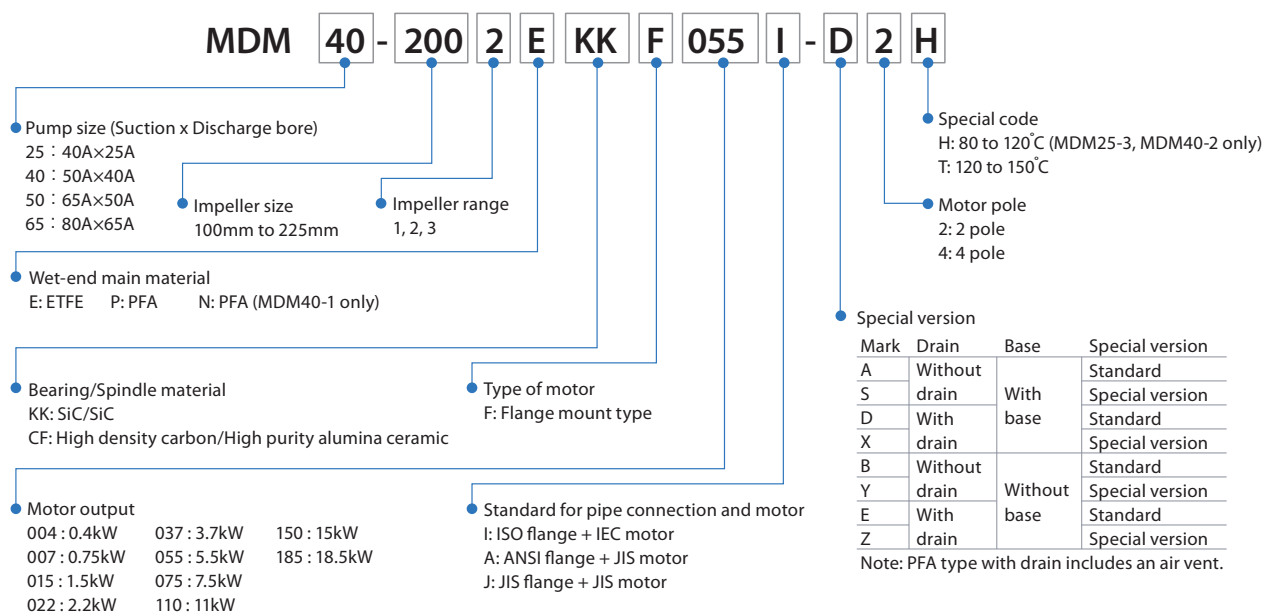
Specification (50/60Hz)

	Model	Pump size Suction x Discharge	50Hz			60Hz			Motor output kW
			Impeller size	Capacity L/min	Head m	Impeller size	Capacity L/min	Head m	
2 Pole motor type	MDM25-1 Impeller range 1	40A×25A	165	100	35.5	140	100	36.0	1.5, 2.2
			160		33.5	130		29.5	
			150		29.0	120		24.5	
			140		25.0	110		20.0	
			130		20.5	100		15.5	
	MDM25-2 Impeller range 2	40A×25A	195	100	50.5	170	100	53.0	3.7, 5.5, 7.5
			190		47.5	160		47.0	
			180		42.5	150		40.5	
			170		37.0	140		35.0	
			160		32.5	130		29.0	
	MDM25-3 Impeller range 3	40A×25A	225	100	74.0	225	100	107.0	5.5, 7.5, 11, 15 or 18.5 (60Hz only)
			220		69.0	220		102.0	
			210		61.0	210		90.0	
			200		55.0	200		80.0	
			190		48.5	190		71.0	
			180		42.5	180		62.5	
			–		–	170		55.0	
			–		–	160		48.0	
	MDM40-1 Impeller range 1	50A×40A	165	208	35.0	145	250	38.0	3.7, 5.5, 7.5
			160		32.5	140		34.5	
			150		28.5	130		29.0	
			140		25.0	120		24.0	
			130		20.5	110		19.5	
			120		17.0	–		–	
	MDM40-2 Impeller range 2	50A×40A	225	208	70.0	225	250	102.0	5.5, 7.5, 11, 15 or 18.5 (60Hz only)
			220		67.5	220		98.0	
			210		60.0	210		87.0	
			200		54.0	200		78.0	
			190		47.0	190		68.0	
			180		41.5	180		60.5	
			170		38.0	170		53.0	
			160		32.0	160		45.0	
	MDM50-1	65A×50A	165	417	33.0	160	500	44.5	3.7, 5.5, 7.5
			160		31.0	150		38.0	
			150		27.0	140		33.0	
			140		22.5	130		27.0	
			130		18.0	120		21.5	
			120		15.0	110		18.5	
			110		12.0	–		–	
	MDM65-1	80A×65A	165	833	38.5	160	1000	51.0	5.5, 7.5, 11, 15 or 18.5 (60Hz only)
			160		35.5	150		44.5	
			150		31.0	140		37.0	
			140		26.5	130		31.5	
			130		22.0	120		26.0	
			120		17.5	110		20.0	
			110		13.5	–		–	
4 Pole motor type	MDM25-1 Impeller range 1	40A×25A	170	50	9.5	170	50	13.0	0.4, 0.75
	MDM25-2 Impeller range 2	40A×25A	200	50	12.5	200	50	18.5	1.5, 2.2, 3.7
	MDM25-3 Impeller range 3	40A×25A	225	50	17.5	225	50	24.0	1.5, 2.2, 3.7, 5.5
	MDM40-1 Impeller range 1	50A×40A	170	200	9.0	170	200	11.5	1.5, 2.2, 3.7
	MDM40-2 Impeller range 2	50A×40A	225	200	15.0	225	200	22.0	1.5, 2.2, 3.7, 5.5
	MDM50-1	65A×50A	170	300	7.5	170	300	11.5	1.5, 2.2, 3.7
	MDM65-1	80A×65A	170	500	8.5	170	500	14.0	1.5, 2.2, 3.7, 5.5

- Max. operating pressure 1.0 MPa (MDM25-3 and MDM40-2 are 1.6 MPa)
- Viscosity limit Please contact us.
- Allowable slurry Hardness 80Hs or less, Particle size 50µm or less, Concentration 5wt% or less (KK type only. Please contact us for more details.)
- Liquid temp. range EKK/ECF type: -20 to 100°C, PKK type: -20 to 150°C, NKK type: -20 to 120°C
(Please contact us when handling liquid temp. is below 0°C or handling liquid temp. is higher than 120°C with PFA type.)
- Installation Ambient temp. 0 to 40°C, Ambient humidity 35 to 85 %RH
- Minimum flow MDM25 (2 pole motor): 20L/min, (4 pole motor): 10L/min, MDM40/50/60 (2 pole motor): 50L/min, (4 pole motor): 20L/min
- Standard motor 2 pole, 3-phase, TEFC, out door flange mount type



Identification



Consumable parts

"Consumable parts" are defined as parts that should be replaced when pump is reassembled.

Parts name	Identification	Materials	Qty	Remarks
Gasket		PTFE	1	
Drain gasket		PTFE	1	
Air vent gasket		PTFE	1	

Spare parts

"Spare parts" are defined as parts that should be replaced periodic maintenance.

IWAKI recommends that the end-user keep the following parts on hand.

Parts name	Identification	Materials	Qty	Remarks
Spindle	PKK	SiC	1	
	ECF	High purity alumina ceramic		
Impeller assembly		Fluoroplastic, etc.	1	Impeller, Mouth ring
Impeller/magnet capsule assembly		Magnet, Fluoroplastic, etc.	1	
Bearing	PKK, EKK, NKK	SiC	1	
	ECF	High density carbon		
Mouth ring	PKK, EKK, NKK	SiC	1	
	ECF	PTFE with filler		
Rear thrust	PKK	PTFE	1	
	EKK, ECF	PTFE with filler		
Rear ring	PKK, EKK, NKK	SiC	1	
	ECF	High purity alumina ceramic		

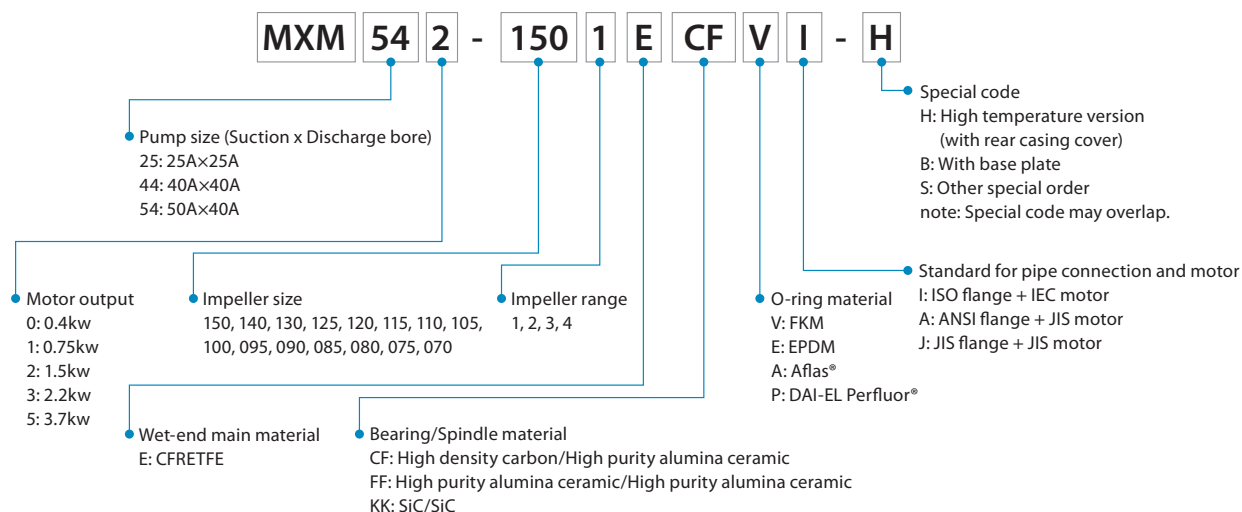
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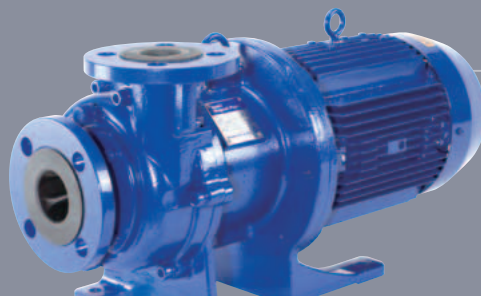
Specification (50/60Hz)

Model	Pump size Suction × Discharge	50Hz			60Hz		
		Impeller size	Capacity L/min	Head m	Impeller size	Capacity L/min	Head m
MXM22 Impeller range 1	25A×25A	100	150	7.5	080	150	6.5
		090	150	5.5	070	150	5
		070	150	2.5	—	—	—
MXM22 Impeller range 2	25A×25A	105	150	8	105	150	14
		—	—	—	090	50	12
MXM44 Impeller range 1	40A×40A	115	200	9.5	120	200	17
		110	200	8	105	100	16
		100	200	6	095	200	9.5
		090	200	5	085	200	7.5
		—	—	—	075	200	5
MXM44 Impeller range 2	40A×40A	130	200	12	130	100	25
MXM54 Impeller range 1	50A×40A	150	200	18.5	150	200	30.5
		140	200	17	140	200	27.5
		120	200	13.5	—	—	—
MXM54 Impeller range 2	50A×40A	—	—	—	130	200	21.5
		—	—	—	120	200	19
		—	—	—	110	200	15
MXM54 Impeller range 3	50A×40A	150	300	20	130	300	26
		140	300	18.5	120	300	20.5
		130	300	16.5	—	—	—
		110	300	10.5	—	—	—
MXM54 Impeller range 4	50A×40A	150	400	25	150	200	41
		140	400	20.5	140	400	29.5
		125	400	15.5	130	400	25
		110	400	9.5	120	400	21.5

- Max. operating pressure MXM22: 0.2MPa, MXM44: 0.3MPa, MXM54: 0.45MPa
- Viscosity limit Less than 120 mPa·s (Please contact us for more details.)
- Allowable slurry Hardness 80Hs or less, Particle size 50μm or less, Concentration 5wt% or less (KK type only. Please contact us for more details.)
- Liquid temp. range Standard model: -10 to 90°C, High temperature version: -10 to 105°C
(The lowest temperature is 10°C when O-ring material is AFLAS®. Please contact us when handling liquid temperature is below 0°C.)
- Installation Ambient temp. 0 to 40°C, Ambient humidity 35 to 85 %RH
- Minimum flow MXM22/44: 10L/min, MXM54 Impeller range 1/2/3: 20L/min, MXM54 Impeller range 4: 50L/min
- Standard motor 2 pole, 3-phase, out door flange mount type

Identification





Consumable parts

"Consumable parts" are defined as parts that should be replaced when pump is reassembled.

Parts name	Identification	Materials	Qty	Remarks
O-ring	V E A P	FKM EPDM Aflas® DAI-EL Perfluor®	1	for Casing
Gasket	V E A P	FKM EPDM Aflas® DAI-EL Perfluor®	2	for Drain

Spare parts

"Spare parts" are defined as parts that should be replaced periodic maintenance.

IWAKI recommends that the end-user keep the following parts on hand.

Parts name	Identification	Materials	Qty	Remarks
Spindle	CF KK	High purity alumina ceramic SiC	1	
Bearing	CF KK	High density carbon SiC	1	
Bearing/Spindle set	FF	High purity alumina ceramic	1	
Mouth ring	CF, FF KK	PTFE with filler SiC	1	
Rear thrust		CFRETFE (MXM22,44) CFRPFA (MXM54)	1	
Magnet capsule assembly	CF KK	CFRETFE, High density carbon CFRETFE, SiC	1	
Magnet capsule assembly/ Spindle set	FF	CFRETFE, High purity alumina ceramic	1	

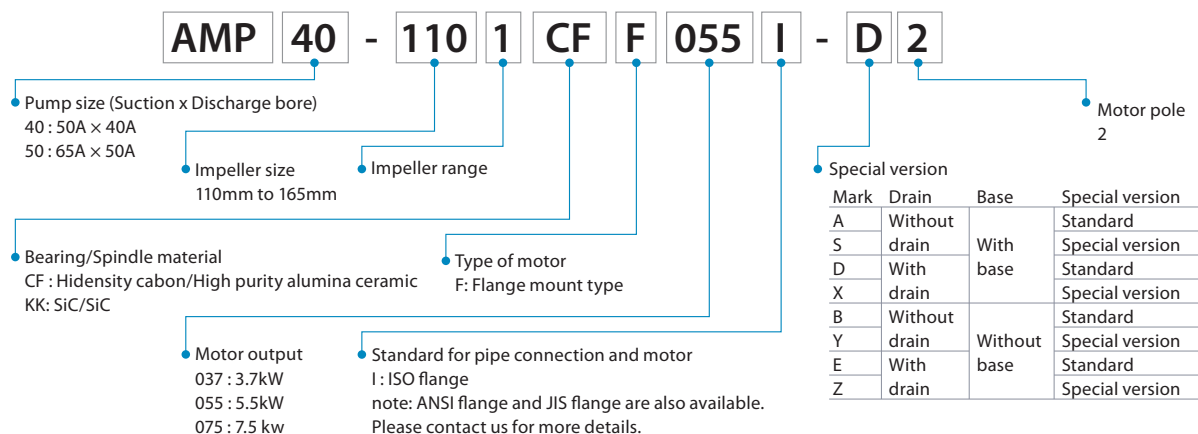
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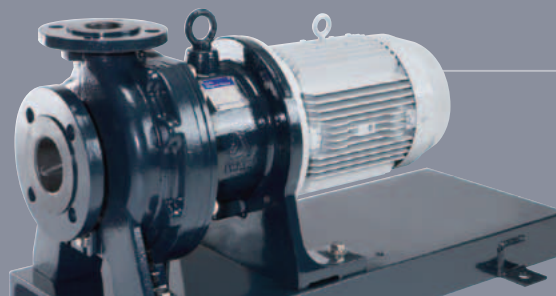
Specification (50/60Hz)

Model	Pump size Suction × Discharge	Impeller size	50Hz		60Hz	
			Capacity L/min	Head m	Capacity L/min	Head m
AMP40-1	50 × 40	165	208	35.0	—	
		160		32.5	250	46.5
		150		28.5		41.0
		140		25.0		34.5
		130		20.5		29.0
		120		17.0		24.0
		110		13.0		19.5
AMP50-1	65 × 50	165	417	33.0	—	
		160		31.0	500	44.5
		150		27.0		38.0
		140		22.5		33.0
		130		18.0		27.0
		120		15.0		21.5
		110		12.0		18.5

- Max. operating pressure 1.0MPa
- Viscosity limit Less than 120 mPa·s (Please contact us for more details.)
- Allowable slurry Hardness 80Hs or less, Particle size 50μm or less, Concentration 5wt% or less (KK type only. Please contact us for more details.)
- Liquid temp. range 0 to 80°C (Please contact us for more details.)
- Installation Ambient temp. 0 to 40°C, Ambient humidity 35 to 85 %RH
- Minimum flow 50L/min
- Standard motor 2 pole, 3-phase, out door flange mount type

Identification





Consumable parts

"Consumable parts" are defined as parts that should be replaced when pump is reassembled.

Parts name	Identification	Materials	Qty	Remarks
Gasket, Casing		PTFE	1	
Gasket, Drain		PTFE	1	

Spare parts

"Spare parts" are defined as parts that should be replaced periodic maintenance.

IWAKI recommends that the end-user keep the following parts on hand.

Parts name	Identification	Materials	Qty	Remarks
Spindle	CF	High purity alumina ceramic	1	
	KK	SiC		
Bearing	CF	High density carbon	1	
	KK	SiC		
Mouth ring	CF	PTFE with filler	1	
	KK	SiC		
Rear thrust ring		PTFE	1	
Rear ring	CF	High purity alumina ceramic	1	
	KK	SiC		
Impeller assembly		CFRPP	1	
Impeller/Magnet capsule assembly		CFRPP	1	

Please contact us for more details.

Related products

Dry run protection device

DR series

The DR series is a dry run protection device that monitors the electric current of the motor. This device will automatically stop the pump when the motor's current draw falls below a set lower limit, runs dry or is overloaded.

- Displays current set value
- Allows upper and lower current control settings
 - Upper limit: Overload
 - Lower limit: Dry running and cavitation
- Built-in current transformer
- DIN rail mounting



Topic Saving energy by using inverters

Energy saving is an important factor in any industrial process.

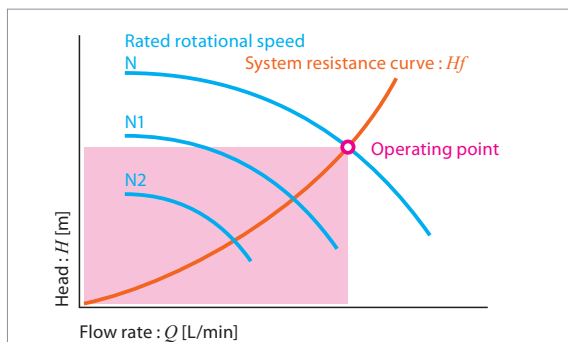
One way to increase the energy efficiency of magnetic drive pumps is through the use of inverters. Any kind of centrifugal pump, including magnetic drive pumps, transfers liquids by using an impeller driven by the rotation of a motor. This means that the pump performance can be fully controlled by varying the rotational speed of the motor using an inverter. You can use the inverter for various purposes including "keeping the flow rate constant", "keeping the pressure constant and increasing energy efficiency".

The approximate variation of pump performance with the rotational speed (N) of the pump is usually described as follows:

$$\text{Flow rate: } Q \propto N \quad \text{Head: } H \propto N^2 \quad \text{Pump input power: } SP \propto N^3$$

For example, This means that at half the rotational speed, the pump's flow rate is reduced by half, its head is reduced to one-quarter and its pump input power is reduced to one-eighth.

The graph shows the relationship between the rotational speed and pump performance.

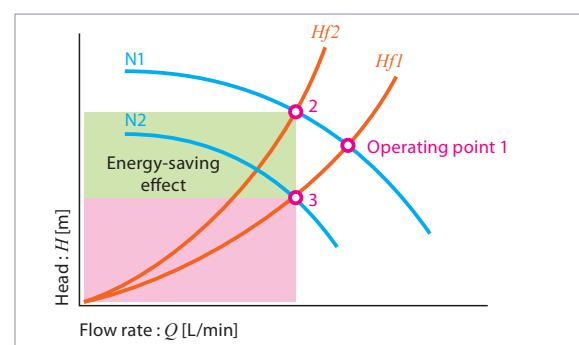


With reference to the rated rotational speed N, the $H-Q$ curves for the slower rotational speeds N1 and N2 are plotted on the graph. Also, the system resistance curve H_f , which varies according to the piping conditions, is provided. The actual operating point is the intersection of each $H-Q$ curve and the system resistance curve. Also, the pump input power is defined as $SP = \rho g Q H / \eta$. Pump efficiency η is assuming the same, Thus the area of a square bounded by the operating point and the origin point of the graph represents the pump input power at each operating point.

The greatest benefit of using inverters is that the pump performance can be controlled without operating a discharge valve to allow various service conditions.

Usually, flow rate is reduced by throttling a discharge valve. With inverter-controlled pumps, the flow rate is reduced by slowing down the rotational speed of the motor.

Following is an example illustrating what happens to the operating point 1, the intersection of the $H-Q$ curve at the rotational speed N1 and the system resistance curve H_{f1} , if the flow rate is reduced. These relationships are plotted on the graph shown below.



To begin with, let's look at when a discharge valve is throttled. As pressure loss increases, the resistance of the pipeline is increased, thus the system resistance curve is shifted to H_{f2} . As a result, the actual operating point shifts up to the operating point 2. On the other hand, in the case when an inverter is used to reduce the rotational speed, the pressure loss stays the same because the valve is not used. This means the system resistance curve H_{f1} also remains the same. However, since the performance of the pump is changed, the $H-Q$ curve shifts to N2. Thus, the actual operating point would shift down to the operating point 3.

When comparing the two cases, it is clear that the pump input power differs widely even through the flow rates are the same. The difference clearly indicates the energy saving effect.

In addition, using an inverter enables soft-starting of the pump resulting in a reduced shock load to the pump and piping at start-up. Reducing the rotational speed can also minimize the load on the sliding parts, thus contributing to the longer life of the pump.

As described above given the energy saving potential and controllability, magnetic drive pumps and inverters are a perfect combination and IWAKI recommends the use of pump and inverters in combination.

Appendix

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Glossary

Basic terms

Pressure

Unit: [Pa]

The force applied per unit area.

Gauge pressure

Unit: [Pa]

The pressure relative to atmospheric pressure. Positive pressure is above atmospheric pressure, and negative pressure is below atmospheric pressure. Usually, the suction pressure and discharge pressure of a pump are expressed as gauge pressure.

Absolute pressure

Unit: [Pa]

The pressure relative to an absolute vacuum. Absolute pressure is always positive, since any pressure cannot be less than an absolute vacuum. Exceptionally, atmospheric pressure and saturated vapor pressure are expressed as absolute pressure.

Atmospheric pressure

Unit: [Pa] Symbol: P_A

The force exerted against a surface by the weight of air above the surface.

Since atmospheric pressure is affected by the altitude of the observation point and pressure distribution at that time, standard pressure is normally used in calculations.

Standard pressure = 101325 [Pa]

Standard pressure is converted into head:

$$\frac{101325}{\rho g} = 10.33 \text{ [m]}$$

ρ : Density of water 1000 kg/m³

g : Acceleration of gravity 9.8 m/s²

Saturated vapor pressure

Unit: [Pa] Symbol: P_v

The pressure existing at a given temperature in a closed vessel containing liquid and vapor from that liquid after equilibrium conditions have been reached. At the point where saturated vapor pressure and ambient pressure is the same, the liquid is changed to gas (boiling phenomenon).

Static pressure

Unit: [Pa] Symbol: P

The pressure that is exerted by fluid on a plane parallel to the flow. Sometimes it is just called pressure. Usually, since the measuring point of a gauge is placed vertically to the flow, the pressure to be measured will generally be static pressure.

Dynamic pressure

Unit: [Pa]

The pressure exerted by fluid on a plane that is not parallel to the flow when it impacts on the surface (that represents the fluid kinetic energy), in addition to the static pressure. The pressure is called dynamic pressure and expressed in the following equation:

$$\rho \frac{V^2}{2}$$

ρ : Liquid density [kg/m³]

V : Average velocity [m/s²]

Total pressure

Unit: [Pa]

The sum of static pressure and dynamic pressure.

$$P + \rho \frac{V^2}{2}$$

Head (Hydraulic head)

Unit: [m]

The mechanical energy contained in fluid per unit weight. The amount of pressure energy, kinetic energy and potential energy are expressed in terms of the equivalent height of the liquid column, which are called the pressure head, velocity head and potential head respectively. All of them are expressed in meters [m].

Pressure head: $\frac{P}{\rho g}$ [m]

Velocity head: $\frac{V^2}{2g}$ [m]

Potential head: H [m]

P : Static pressure [Pa]

ρ : Density [kg/m³]

g : Acceleration of gravity [9.8 m/s²]

V : Average flow velocity [m/s]

H : Height from the reference plane [m]

Total head

Unit: [m]

The sum of pressure head, velocity head and potential head.

$$\frac{P}{\rho g} + \frac{V^2}{2g} + H \text{ [m]}$$

Density

Unit: [kg/m³] Symbol: ρ

The weight per unit volume.

Water is also called incompressible fluid, since its volume i.e. density is hard to change. Therefore, the density of water is always assumed to be 1000 kg/m³ in calculations in these guidelines.

Specific gravity

Symbol: γ

The ratio of density of a substance to the density of water. Usually, the density of water is assumed to be 1000 kg/m³ in calculations.

$$\gamma = \frac{\rho}{\rho_w}$$

ρ : Density of a given liquid [kg/m³]

ρ_w : Density of water [kg/m³]

FYI: Physical properties of water

Temperature	[°C]	0	20	100
Density	[kg/m ³]	999.9	998.2	958.4
Viscosity	[mPa·s]	1.79	1.00	0.28
Saturated vapor pressure	[kPa]	0.61	2.34	101.13
	[mHz0]	0.06	0.24	10.31

All the data in the table above are measured at standard atmospheric pressure (0.1013MPa).

Viscosity

Unit: [Pa·s] Symbol: μ

The quantity that describes the degree of viscosity of a fluid. Viscosity is specific to each liquid, but it varies with the liquid's temperature and concentration. It is conventionally expressed in [mPa·s] in many situations. [cP] was used in the former system of units.

FYI: Viscosity of various liquids [mPa·s]

(at room temperature)

Methyl alcohol	0.42
Ethyl alcohol	0.91
Water	1
Soy sauce	4.76
Salad oil	54.5
Nail varnish	448
Tomato ketchup	2030
Mayonnaise	3030

(Reference values)

Kinematic viscosity

Unit: [m²/s] Symbol: ν

The value obtained by dividing viscosity by density. It indicates the reluctance of a fluid to flow. It is conventionally expressed in cSt in many cases.

$$\nu = \frac{\mu}{\rho}$$

μ : Viscosity of a given liquid

ρ : Density

Newtonian fluid

A fluid whose shearing stress due to viscosity (τ) is proportional to the shear rate (du/dy). Most of the liquids found in nature are classified as Newtonian fluids. The viscosity correction method mentioned in these guidelines is directed at Newtonian fluids.

$$\tau = \mu \frac{du}{dy}$$

Non-Newtonian fluid

A fluid whose shearing stress due to viscosity (τ) is NOT proportional to the shear rate (du/dy).

Bingham fluid

A fluid that does not begin to flow until a certain stress is applied, e.g. ink, margarine and toothpaste.

Pseudoplastic fluid

A fluid whose viscosity decreases as stress increases, e.g. high polymers, paints, mayonnaise and ketchup.

Dilatant fluid

A fluid whose resistance to flow increases proportionally with the increase of shear rate, e.g. whipped cream, and starch mixed with water.

Pump Performance

Pump reference plane

Reference plane used in various calculations. Typically placed on the center line of the pump suction inlet.

Discharge head

Unit: [m] Symbol: h_d

Pressure of pump discharge outlet expressed as a head [m].

Discharge static head

Unit: [m] Symbol: H_d

Height of the fluid level on the discharge side from the pump reference plane.

Suction head

Unit: [m] Symbol: h_s

Pressure of pump suction inlet expressed as a head [m].

Suction static head

Unit: [m] Symbol: H_s

Height of the fluid level on the suction side from the pump reference plane.

System static head

Unit: [m] Symbol: H_{ac}

Difference between the discharge static head (H_d) and suction static head (H_s).

Total head

Unit: [m] Symbol: H

Difference between the total discharge head at discharge outlet and total suction head at the suction inlet.

$$\begin{aligned} \text{Total suction head: } H_1 &= \frac{p_1}{\rho g} + \frac{V_1^2}{2g} + h_1 \quad [\text{m}] \end{aligned}$$

$$\begin{aligned} \text{Total discharge head: } H_2 &= \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + h_2 \quad [\text{m}] \end{aligned}$$

$$\begin{aligned} \text{Total head: } H &= H_2 - H_1 \\ &= \frac{p_2 - p_1}{\rho g} + \frac{V_2^2 - V_1^2}{2g} + h_2 - h_1 \quad [\text{m}] \end{aligned}$$

p_1 : Static pressure on suction side [Pa]

V_1 : Flow velocity on suction side [m/s]

h_1 : Height of the suction pressure gauge [m]

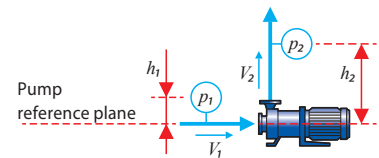
p_2 : Static pressure on discharge side [Pa]

V_2 : Flow velocity on discharge side [m/s]

h_2 : Height of the discharge pressure gauge [m]

ρ : Fluid density [kg/m³]

g : Acceleration due to gravity [9.8 m/s²]



Total system head

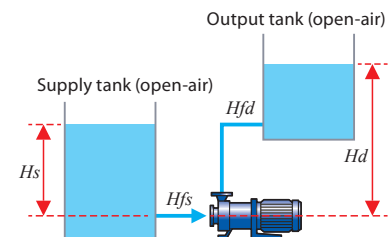
Unit: [m] Symbol: H_t

Head required to pump fluid at a given flow rate through a series of pipe systems from the supply tank to the output tank. Sum of the change in elevation between the supply tank and output tank together with the pipe resistance.

- For open-air tanks

Total system head: H_t

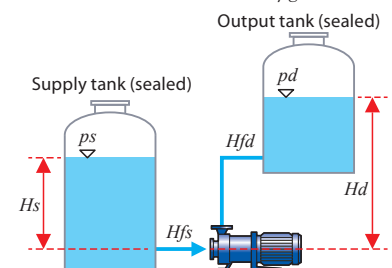
$$= H_d - H_s + H_{fs} + H_{fd} \quad [\text{m}]$$



- For sealed tanks

Total system head: H_t

$$= H_d - H_s + H_{fs} + H_{fd} + \frac{(pd - ps) \times 10^6}{\rho g} \quad [\text{m}]$$



H_s : Suction static head [m]

H_d : Discharge static head [m]

H_{fs} : Suction friction head loss [m]

H_{fd} : Discharge friction head loss [m]

pd : Pressure inside output tank [MPa]

ps : Pressure inside supply tank [MPa]

ρ : Fluid density [kg/m³]

g : Acceleration of gravity [9.8 m/s²]

Pipe resistance

Unit: [m] Symbol: H_f

Pressure loss due to friction between the wall of a pipe and the fluid passing through the pipe, expressed as a head [m].

The pipe resistance is calculated using the Darcy-Weisbach equation below.

$$\text{Pipe resistance: } H_f = f \frac{L}{D} \frac{V^2}{2g} \quad [\text{m}]$$

f : Friction coefficient

($0.02 + 0.0005/D$ for new pipes)

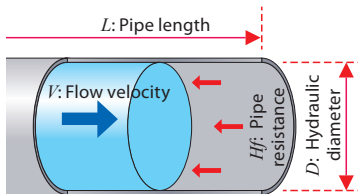
L : Pipe length [m]

D : Hydraulic diameter [m]

(use the inner diameter of the pipe)

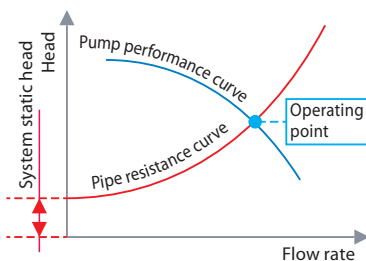
V : Fluid velocity [m/s]

g : Acceleration of gravity [9.8 m/s^2]



Pipe resistance curve (system curve)

Curve showing the relationship between system values (obtained by adding the system static head to the pipe resistance) and the flow rate. Pipe resistance is proportional to the square of flow velocity, so the pipe resistance curve is a quadratic function. The operating point of the pump is the intersection between the pipe resistance curve and the pump performance curve.



Shaft power

Unit: [kW] Symbol: SP

Mechanical power transmitted to a pump from a motor.

Water (hydraulic) power

Unit: [kW] Symbol: P_w

Power transmitted to a fluid as it travels through a pump.

$$\text{Waterpower: } P_w = 0.163 \times \gamma Q H \times 10^{-3} \quad [\text{kW}]$$

γ : Specific gravity

Q : Flow rate [m^3/min]

H : Total head [m]

Pump efficiency

Unit: [%] Symbol: η

Ratio between the water (hydraulic) power and shaft power.

$$\text{Pump efficiency: } \eta = \mu \frac{\text{Water power: } P_w \text{ [kW]}}{\text{Shaft power: } SP \text{ [kW]}} \quad [\%]$$

Shaft power

Unit: [kW] Symbol: SP

Mechanical power transmitted to a pump from a motor.

Overall efficiency

Unit: [%] Symbol: η_{gr}

Ratio between the net power entering a pump system, including the drive system, and the water (hydraulic) power. If using an inverter drive system, the loss in the inverter must also be taken into account.

$$\text{Over all efficiency: } \eta_{gr} = \frac{P_w}{P_{in}} \quad [\%]$$

P_w : Water power [kW]

P_{in} : Input power [kW]

Cavitation

Creation of vapor bubbles in areas of the flowing fluid where the fluid pressure locally drops to the fluid vapor pressure. In a centrifugal pump, cavitation generally occurs at the impeller inlet where the pressure is lowest, reducing pump performance and causing vibration and noise.

NPSHa

(net positive suction head available)

Unit: [m]

NPSH available.

Net positive head available at the suction inlet of a pump. Specifically, a measure of the amount of energy that pushing fluid into the suction inlet of a running pump expressed as a head [m].

It is unrelated to the pump, and is determined by the fluid properties and pipe conditions.

NPSHr

(net positive suction head required)

Unit: [m]

NPSH required.

The minimum NPSH required to prevent cavitation in a pump.

It is unrelated to fluid properties and pipe conditions, and is a characteristic of each pump.

Abnormal Operation

Cavitation operation

The running of a pump in which cavitation is occurring.

In general, cavitation occurs when the NPSHa value drops below the NPSHr of the pump due to deterioration in the suction conditions.

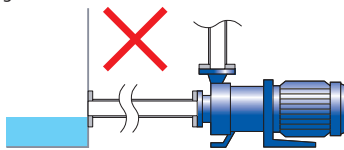
During cavitation, vapor bubbles are continuously forming and collapsing in the fluid inside the pump, leading to a reduction in pump performance and greatly increased vibration and noise. In severe cases, in addition to the significant reduction in pump performance, cavitation causes mechanical erosion of the surfaces of wet ends and overheating of sliding parts.

Dry running

The running of a pump with no fluid inside the pump.

Dry running is strictly prohibited for all centrifugal pumps, not just magnetic pumps. In particular, there is a danger of bearing failure in large-size pumps even after a very short period of dry running.

However, models fitted with carbon bearings are designed to withstand up to an hour of dry running.



Semi-dry running

The running of a pump that is only about half full of fluid inside pump chamber.

In semi-dry running the fluid inside the pump is aggressively thrown about, and may cause as much damage or even more damage than dry running.

Air entering operation

The running of a pump with fluids containing air (gas, vapor).

Air entering operation can considerably reduce cooling of sliding components and must be avoided. Also, if a large volume of air enters the pump, it may lose pumping action and cause a vapor lock condition.

Discharge-side shut off operation

The running of a pump with the discharge-side valve closed.

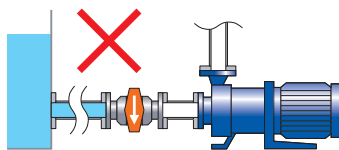
This is not a problem for short periods, but if a pump runs in this condition for a lengthy period, the temperature of fluid in the pump will increase and may lead to failure of sliding components.

If running with the discharge valve closed to check shut off pressure or other reason, keep the running time as short as possible.

Suction-side shut off operation

The running of a pump with the suction-side valve closed.

This is strictly prohibited for all centrifugal pumps, not just magnetic pumps. Suction-side shut off operation significantly reduces the suction pressure and may damage the pump in a relatively short time.



Running below the minimum flow rate

The minimum flow rate, determined for each pump, is the minimum flow required to ensure cooling of sliding components.

Running below the minimum flow rate will provide insufficient cooling to sliding components, leading to overheating and premature wear.

Reverse rotation

The normal direction of rotation is clockwise as viewed from the motor. Reverse rotation is counterclockwise rotation.

In reverse rotation, the H-Q performance drops and the flow rate drops to less than half, compared to the normal direction of rotation.

Eddy current

If you try to move a conductor rapidly through a strong magnetic field, an opposing (braking) force is generated. The opposing magnetic force is caused by a circulating current generated in the conductor due to electromagnetic induction. The current giving rise to the opposing magnetic field is called an eddy current.

Surging

The periodic changing of pressure and flow rate while pump running.

A pump is more susceptible to surging when operated at the peaks or flats of the pump performance curve.

Surging is often caused by aspects of the pipe system that have a spring-like nature. (for example, air accumulation or elastic pipe fittings.)

Decoupling operation

A state when running the pump where the drive magnet and driven magnet are not synchronized (pole slip).

In normal operation, the drive magnet and driven magnet rotate synchronously (same speed with no pole slip). However, if an excessive load is applied on the pump side, the driven magnet cannot keep up with the drive magnet and pole slip occurs.

In step-out running, the pumping of fluid is essentially disabled when the impeller rpm drops to about 1/5 of the motor rpm. Also, if the decoupling state continues for a lengthy duration, heat will be generated in rotating components due to the formation of eddy currents, reducing the strength of the magnetic coupling.

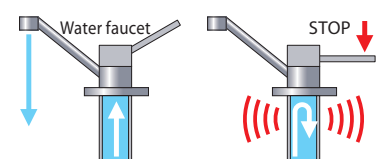
When the decoupling state occurs, completely stop the pump and remove the problem before restarting the pump.

Water hammer

Shocks due to high-pressure fluctuations inside pipes caused by rapid changes in flow velocity, such as when valves are operated quickly or a pump is started when connected to long pipes.

The impact pressure generated propagates a surge in the pipe system back and forth, which may damage the pump, meters, and gauges.

To prevent water hammering, open and close valves slowly, and install check valves in long discharge pipes. The use of electromagnetic valves that open and close rapidly is strictly prohibited.



Thermal shock

Rapid heating and cooling.

When differences in temperature occur within the pump, internal stress due to thermal expansion occurs. This internal stress can cause cracks in components. Fragile materials such as ceramics are particularly susceptible.

In magnetic pumps, thermal shock can occur when the pump is primed immediately after a period of inadvertent dry running. If dry running occurs, it is essential to allow sliding components, such as bearings, at least 1 hour to cool before priming the pump.

Blistering

Damage to plastic materials caused by chemical permeation into the plastic.

Gas permeates the surface of the plastic and penetrates the plastic material. Before fully penetrating the material, the gas condenses into fluid state, forming blisters under the surface of the material.

Blistering is caused by susceptibility to chemical permeation, and is independent of the corrosion resistance of the material. This can also occur in the lining of pipes used to alternately transfer high-temperature high-pressure steam and cold water. The plastic material itself is not seriously degraded, but blisters can cause trouble due to contact with rotating components and loss of mechanical strength.

Wet-end parts materials

Fluoroplastics

Generally, synthetic polymers that contain fluorine atoms (F) in their molecular structure are called fluoroplastics.

PTFE

Polytetrafluoroethylene

Typical kind of fluoroplastics most widely used world-wide. The characteristics of fluoroplastics are maximized in this material. PTFE has the highest level heat resistance, chemical resistance and dielectric properties among thermoplastic resins. It has a non-cohesive and low friction surface without any water absorbing properties. It does not become brittle even at cryogenic temperatures (4 K). Since its mechanical characteristics include good flexibility, toughness and large deformation under load, PTFE is suitable as a sealing material.

When used in sliding parts as machine components, inorganic fillers such as glass and carbon are added.

Although PTFE is poor in formability since it does not flow even at temperatures higher than its melting point (327°C), it has exceptional heat resistance.

PFA

Tetrafluoroethylene/perfluoroalkoxy vinyl ether copolymer

A type of fluoroplastic that can be injection molded, while maintaining the excellent properties of PTFE. This has become possible by the modification of its molecular structure.

Major brands include the DuPont™ Teflon® PFA by DuPont U.S.A.

ETFE

Ethylene/tetrafluoroethylene copolymer

A type of fluoroplastic that has excellent electric characteristics and mechanical toughness. In addition, it has the same level of chemical resistance as PFA. It is also known for its excellent formability and workability.

However, ETFE is attacked by organic halogens (that include C (carbon) in their chemical formula) and halogens (that include F (fluorine), Cl (chlorine), Br (bromine) etc. in their chemical formula).

CFRPFA/CFRETFE

Carbon-fiber-reinforced fluoroplastics.

Reinforced by carbon fibers, which have drastically increased its mechanical strength to enhance the stability of its measurements. They have the same level of chemical resistance as non-reinforced fluoroplastics.

Typical properties of plastics

Property	Unit	ASTM testing method	PTFE	PFA	ETFE	PP
Melting point	°C	-	327	300 to 310	270	165
Specific gravity	-	D792	2.14 to 2.20	2.12 to 2.17	1.70	0.91
Tensile strength	MPa	D638	27 to 34	24 to 34	45	32
Elongation	%	D638	200 to 400	300	100 to 400	500
Compressive strength	MPa	D695	12	17	49	49
Impact strength (Izod)	J/m	D256A	160	---	---	29
Hardness (Izod)	-	D785	-	-	R50	-
Hardness (Shore)	-	D2240	D50 to 65	D64	D75	-
Hardness (Rockwell)	-	D785	R20	R50	R50	R97
Flexural modulus	GPa	D790	0.55	0.66 to 0.69	1.4	-
Tensile modulus	GPa	D638	0.40 to 0.55	-	0.82	0.7
Heat conductivity	W/m·K	C177	0.25	0.25	0.24	0.1
Specific heat	10 ³ J/kg·K	D240	1.0	1.0	1.9 to 2.0	1.92
Coefficient of linear expansion	10 ⁻⁵ /K	D696	10	12	5.9	11
Deflection temperature under load (1.8MPa)	°C	D648	55	50	74	60 to 65
Deflection temperature under load (0.45MPa)	°C	D648	121	74	104	115
Maximum operating temperature	°C	-	260	260	150 to 180	120
Volume resistivity	Ω·cm	D257	>10 ¹⁸	>10 ¹⁸	>10 ¹⁶	>10 ¹⁶

The above data is an excerpt from the published value of the material manufacturer.

CFRPP

Carbon-fiber-reinforced polypropylene (PP) makes the most of the excellent properties of PP, including chemical resistance and a light weight. It has been mixed with carbon fibers so that it can bear heavy duty applications.

Sliding parts materials

SiC

Silicon carbide

The second hardest material after the diamond, which has seven to eight times the hardness of iron.

Since it has excellent chemical resistance, it enables almost all chemicals to be handled; However, it may sometimes be oxidized by strong oxidizers such as potassium permanganate and ozone. Sometimes, it may break or chip by an impact.

Alumina ceramics

Aluminum oxide

Alumina ceramics have approximately five times the hardness of iron, although they are not as hard as SiC. Since they have excellent chemical resistance, almost all chemicals can be handled. However, they may sometimes be eroded by strong alkalis at high temperatures. Variants with increased purity are called high-purity alumina ceramics. The higher the purity level, the greater the strength and chemical resistance of the substance.

Carbon

Carbon material

Since it is less resistant to chemicals than SiC and alumina ceramics, it may be eroded by strong-acid chemicals. The most distinguishing feature of carbon is its high self-lubricating capability. It shows excellent low friction characteristics even under dry environments.

Filled PTFE

PTFE is reinforced by inorganic fillers to increase the sliding properties. It has not only the same level of chemical resistance as PTFE, but also excellent sliding properties. However, it may NOT be suitable for use in sliding parts of a pump; since it has a high coefficient of linear expansion. Heat generation caused by abnormal operation may result in shorter clearance between components, thus causing sticking.

Typical properties of sliding parts materials

Property	Unit	JIS testing method	SiC	Alumina (Al ₂ O ₃)	Carbon	Filled PTFE
Apparent specific gravity	-	C2141	3.16	3.9	1.9	2.1
Hardness (Vickers)	GPa	R1610	23	16	-	-
3-point flexural strength	MPa	R1601	450	360	98	-
Tensile strength	MPa	-	-	-	-	17.6
Compressive strength	MPa	-	-	2350	215	-
Elongation	%	-	-	-	-	100
Young's modulus	GPa	R1602	440	370	12.7	0.94
Poisson's ratio	-	R1602	0.17	0.23	0.2	-
Coefficient of linear expansion	10 ⁻⁶ /°C	R1618	3.7	7.2	5.8	80
Heat conductivity	W/m·K	R1611	200	32	70	0.43
Specific heat	J/kg·K	R1611	670	780	700	-
Thermal shock resistance (when dropped into water)	°C	-	400	250	-	-
Volume resistivity	Ω·cm	C2141	10 ⁸	>1014	-	7×10 ⁵

The above data is an excerpt from the published value of the material manufacturer.

Sealing materials

FKM (O-ring material)

Fluorine rubber

Fluorine rubber has outstanding resistance to heat, oil, chemicals and atmospheric corrosion.

Although it can handle a wide variety of chemicals, strong alkaline, anhydrous ammonia and active amines will cause deterioration.

Operating temperature range: -10 to 200 °C

EPDM (O-ring material)

Ethylene propylene rubber

A type of synthetic rubber that is obtained by copolymerization of ethylene and propylene. It is particularly resistant to ozone, but has poor resistance to oils such as mineral oil and organic solvent.

Operating temperature range: -45 to 130°C

Aflas® (O-ring material)

Tetrafluoro ethylene/propylene rubber (FEP)

A fluor elastomer developed by the Asahi Glass Co., Ltd. that has better chemical resistance than other fluorinated elastomers. It suffers little deterioration even in the presence of strong acids and strong bases at high temperatures.

Typical fluor elastomers (FKM) are quite susceptible to deterioration from amine rust-preventive agents and amine additives contained in oil and grease, whereas Aflas® provides good chemical resistance to them. It is not suitable for use at low temperatures because it loses elasticity.

Operating temperature range: 10 to 200°C

DAI-EL Perfluor® (O-ring material)

Tetrafluoro ethylene/perfluoro-methylvinyl ether rubber (FFKM)

High polymer material developed by DAIKIN INDUSTRIES, LTD. that is categorized as per-fluoroelastomer (FFKM).

DAI-EL Perfluor® has a chemical structure that consists of carbon, fluorine and oxygen atoms only. It provides outstanding chemical resistance to any kind of chemicals and solvents.

Operating temperature range: -10 to 200°C

Kalrez® (O-ring material)

Perfluoroelastomer developed by DuPont U.S.A.

Combining the strong chemical resistance of fluoroplastics and the elasticity inherent in rubber, Kalrez® delivers the highest performance among all the elastomers commercially available today.

It demonstrates outstanding sealing performance even at high temperatures.

Operating temperature range: -10 to 300°C

PTFE (gasket material)

PTFE covered gaskets

With a special core covered with PTFE, gaskets can deliver both strong chemical resistance and sealing capability.

The sealing performance of gaskets will vary depending on the tightening torque of the seal. Therefore, accurate torque control and periodic retightening are absolutely necessary.

Operating temperature range: -50 to 180°C

Power supply voltage in major countries

Country/region	Frequency	Single phase	Three phase
Australia	50 Hz	240 V	415 V
Austria	50 Hz	230 V	400 V
Argentina	50Hz	220 V	380 V
Belgium	50 Hz	230 V	400 V
Brazil	60 Hz	127 V	220 V
Bulgaria	50 Hz	220 V	380 V
Canada	60 Hz	120/347 V	208/240/600 V
Chile	50 Hz	220 V	380 V
China	50 Hz	220 V	380 V
Czech	50 Hz	230 V	380 V
Denmark	50 Hz	230 V	400 V
England	50 Hz	240 V	415 V
Finland	50 Hz	230 V	400 V
France	50 Hz	230 V	400 V
Germany	50 Hz	230 V	400 V
Greek	50 Hz	230 V	400 V
Hong Kong	50 Hz	200/220 V	346/380 V
Holland	50 Hz	230 V	400 V
Hungary	50 Hz	220 V	380 V
India	50 Hz	230 V	240/415 V
Indonesia	50 Hz	220 V	380 V
Ireland	50 HZ	230 V	400 V
Italy	50 Hz	220 V	380 V

Country/region	Frequency	Single phase	Three phase
Japan	50/60 Hz	100/200 V	200 V
Luxembourg	50 Hz	230 V	400 V
Malaysia	50 Hz	240 V	415 V
Mexico	60 Hz	120/125/127 V	220/480 V
Myanmar	50 Hz	230 V	230/400 V
Netherlands	50 Hz	230 V	400 V
New Zealand	50Hz	230 V	230/415 V
Norway	50 Hz	220/230 V	380 V
Peru	60 Hz	220 V	220 V
Philippines	60 Hz	115/230 V	240/480 V
Poland	50 Hz	220 V	380 V
Portugal	50 Hz	230 V	400/480 V
Romania	50 Hz	220 V	380 V
Singapore	50 Hz	230 V	400 V
South Korea	60 Hz	110/220 V	200/220/380 V
Spain	50 Hz	127/220 V	220/380 V
Sweden	50 Hz	230/400 V	400/690 V
Switzerland	50 Hz	230 V	400 V
Taiwan	60 Hz	110/220 V	220/380 V
Thailand	50 Hz	220 V	220/380 V
United States	60 Hz	115/230 V	230/460 V
UAE	50Hz	220/240 V	380/415 V
Vietnam	50 Hz	220 V	380 V

Note: Voltages other than listed above may be used in some countries or cities.

Unit conversion table

Length

m	cm	mm	in	ft
1	100	1000	39.37	3.28083
0.01	1	10	0.3937	0.032808
0.001	0.1	1	0.03937	0.0032808
0.0254	2.540	25.40	1	0.0833
0.3048	30.48	304.8	12	1

Area

m ²	cm ²	ft ²
1	10000	10.7639
0.0001	1	0.0010764
0.9290	929	1

Volume

L	m ³	gal(US)	gal(UK)	ft ³
1	0.001	0.2642	0.2200	0.035316
1000	1	264.20	219.96	35.316
3.7854	0.0037854	1	0.8327	0.13368
4.5459	0.0045459	1.2009	1	0.16053
28.32	0.02832	7.4808	6.228	1

Mass

kg	lb	t (long ton)	t (short ton)
1	2.20462	0.0009842	0.001102
0.45359	1	0.0004464	0.00050
1016.05	2240	1	1.12
907.185	2000	0.89286	1

Fluid

L/s	L/min	L/h	m ³ /h	gal/min(US)	gal/min(UK)	ft ³ /h
1	60	3600	3.6	15.85	13.198	127.14
0.016667	1	60	0.06	0.2642	0.2200	2.119
0.000278	0.016667	1	0.001	0.004403	0.003667	0.035316
0.2778	16.668	1000	1	4.403	3.666	35.316
0.06309	3.7854	227.124	0.227124	1	0.8327	8.0208
0.07578	4.5468	272.808	0.272808	1.201	1	9.6318
0.007866	0.47196	28.32	0.02832	0.12468	0.1038	1

Temperature

$$^{\circ}\text{C} = \frac{5}{9} (^{\circ}\text{F} - 32)$$

$$^{\circ}\text{F} = \frac{5}{9} (^{\circ}\text{C} + 32)$$

Pressure

Pa	kPa	MPa	bar	kgf/cm ²	atm	mH ₂ O	mmHg(Torr)	lbf/in(psi)
1	1×10 ⁻³	1×10 ⁶	1×10 ⁵	1.020×10 ⁻⁵	9.869×10 ⁻⁶	1.020×10 ⁻⁴	7.501×10 ⁻³	1.450×10 ⁻⁴
1×10 ³	1	1×10 ⁻³	1×10 ⁻²	1.020×10 ⁻²	9.869×10 ⁻³	1.020×10 ⁻¹	7.501	1.450×10 ⁻¹
1×10 ⁶	1×10 ³	1	1×10	1.020×10	9.869	1.020×10 ²	7.501×10 ³	1.450×10 ²
1×10 ⁵	1×10 ²	1×10 ⁻¹	1	1.020	9.869×10 ⁻¹	1.020×10	7.501×10 ²	1.450×10
9.807×10 ⁴	9.807×10	9.807×10 ⁻²	9.807×10 ⁻¹	1	9.678×10 ⁻¹	1.000×10	7.356×10 ²	1.422×10
1.013×10 ⁵	1.013×10 ²	1.013×10 ⁻¹	1.013	1.033	1	1.033×10	7.600×10 ²	1.470×10
9.807	9.807×10 ⁻³	9.807×10 ⁻⁶	9.807×10 ⁻⁵	1.000×10 ⁻⁴	9.678×10 ⁻⁵	1	7.356×10 ⁻²	1.422
1.333×10 ²	1.333×10 ⁻¹	1.333×10 ⁻⁴	1.333×10 ⁻³	1.360×10 ⁻³	1.316×10 ⁻³	1.366×10 ⁻⁴	1	1.934×10 ⁻²
6.895×10 ³	6.895	6.895×10 ⁻³	6.895×10 ⁻²	7.301×10 ⁻²	6.805×10 ⁻²	7.031×10 ⁻⁴	5.172×10	1

Viscosity

Pa·s	mPa·s (cP)	P
1	1×10 ³	1×10
1×10 ⁻³	1	1×10 ⁻²
1×10 ⁻¹	1×10 ²	1

Kinetic viscosity

m ² /s	cSt	St
1	1×10 ⁶	1×10 ⁴
1×10 ⁻⁶	1	1×10 ⁻²
1×10 ⁻⁴	1×10 ²	1

Power

kgf·m/s (N)	kW	PS
1	0.00980665	0.01333
101.972	1	1.35962
75	0.7355	1

Note: as a reference only above, please check if necessary.

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Caution for safety use:

Before use of pump, read instruction manual carefully to use the product correctly.



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