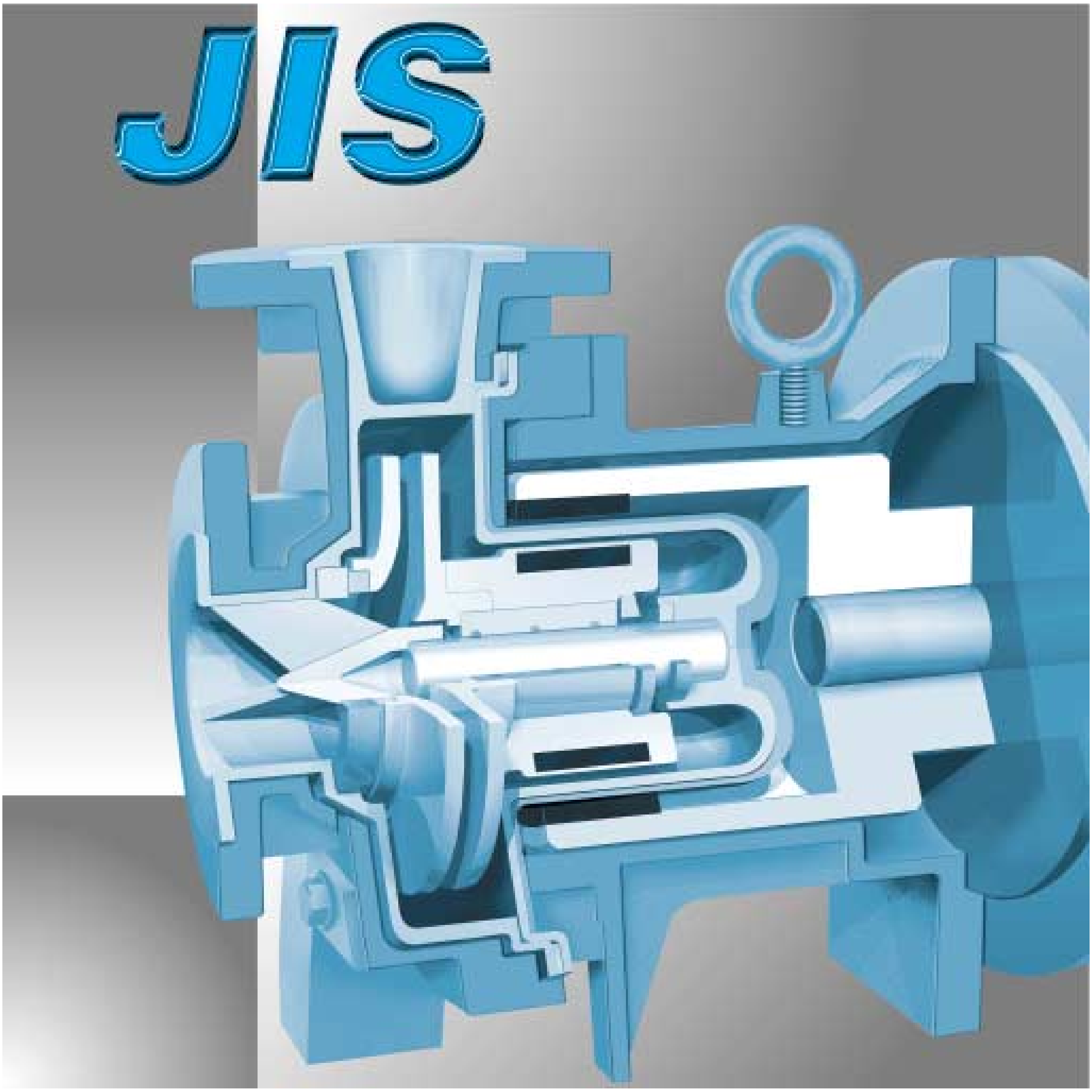
MAN.No.0010-2A

MDM SERIES

Iwaki Magnetic drive Pumps

technical information



advanced pump technology

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1. General description

MDM is a new series of fluoro-plastics made magnet drive pump for chemical processing application. All models of this series till 15kW model employ "Non-contact system" , which makes the pump dry running possible. This new construction improves the safety and endurance against dry running operation. (Dry running operation is possible with high density carbon bearing type)
Basic construction employs fixed spindle with which IWAKI has been well experienced. In addition to ETFE, natural PFA is standardized as wet-end parts material, which enables to transfer not only various chemicals such as strong acids or alkalis but also ultra-pure chemicals used in semiconductor industries.

Main advantages:

1. Dry running is possible with all models of MDM.
In addition to smaller than 5.5kW models, now 5.5 to 15kW models are dry running possible.

2. Small flow and high head types are available.
High head of 50m at 100 L/min. flow

3. PFA material type is standardized.
New PFA is employed.

4. SiC is standardized for all rubbing parts.
Improved durability and reliability

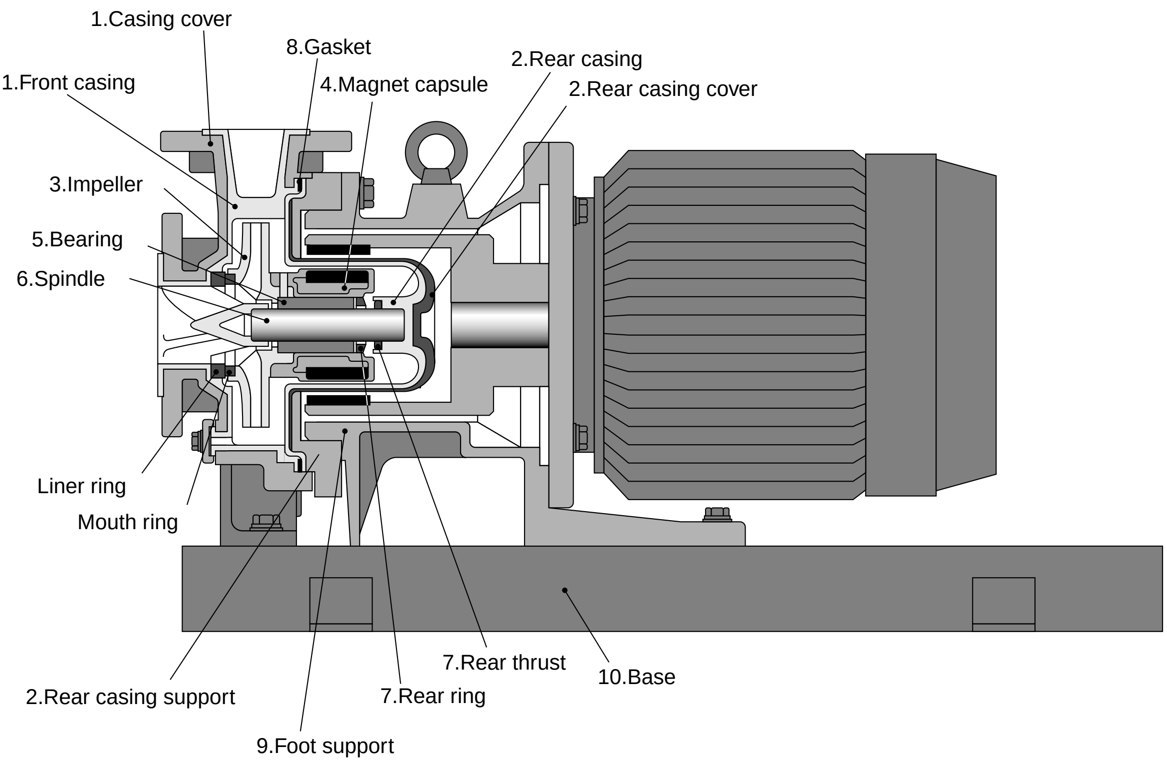
5. Back pull-out
Removal and mounting of foot support are possible without liquid leakage.

6. Installation interchangeability with other pumps
Interchangeable with MDF-L, MDF-M and MDE.

Dry running possible construction. [Non-contact system]

"Non-contact system" is the method so that a magnet capsule can not touch rear thrust ring when the pump runs dry. This is realized by the arrangement of both driving and driven magnets to control the movement of magnet capsule. In addition to dry running, when the pump runs with air sucking in, it happens that the magnet capsule moves back and forward. When the magnet capsule moves backward, the rear ring which is mounted on magnet capsule rubs rear thrust ring to keep down the heat generation and to protect the adjacent plastic materials from melting.
(Note)When the pump ran dry, leave it for one hour for cooling down.
Ceramic parts may be broken by heat shock if the liquid gets into the pump just after it ran dry.

2. Construction and materials



2-1Explanation of each part

1. Front casing/Casing cover

ETFE type

Front casing is made by injection molding of carbon fiber reinforced ETFE.

The fluororesin is covred by ductile iron to obtain enough pressure resistance and to endure piping load.

Both types with drain and without drain are available.

PFA type

Casing cover and natural new PFA are integrally made. Contamination and particles free clean material.

2. Rear casing/Rear casing cover

Double layers construction that the rear casing made by carbon fiber reinforced ETFE (or natural PFA) is protected by rear casing cover made by carbon fiber reinforced Plastic endures to 1.0 MPa pressure. No eddy current loss and no spark even if the drive magnet touches the cover, which realizes high reliability compared to conventional metallic cover.

Rear casing is fixed by bolts through the rear casing support to front casing side, which makes sealed parts not loosened and no leakage when motor and foot support are pulled out backward.

3. Impeller

Impeller is made by injection molding of carbon fiber reinforced ETFE (or natural PFA). It is connected by spline to magnet capsule. A pin is employed to avoid the impeller coming out axially(PAT. PEND.). Impeller itself can be replaced.

4. Magnet capsule (Driven magnet)

Strong rare earth magnet is employed to make it compact and light weight. Utilizing the strength of magnet force, the magnet capsule is designed to always keep its neutral position and to restrict its axial direction movement. The magnet is molded by carbon fiber reinforced ETFE (or natural PFA).

5. Bearing

Two materials are available as standard. One is high density carbon which is strong against dry running and another is SiC which has superior resistance to wear. The bearing is inserted into the magnet capsule and can be replaced by itself.

6. Spindle

Spindle is supported by spindle supports of front casing and rear casing. (Fixed spindle style). As materials, SiC and high purity alumina ceramic are available, i.e. SiC spindle vs SiC bearing and high purity alumina ceramic spindle vs high density carbon bearing.

7. Rear ring/Rear thrust

In case that the magnet capsule moves to backward due to abnormal operation such as air sucking etc., the rear ring rubs rear thrust, which generates shock and heat. Contact area of rear ring is minimized to restrain heat generation. As rear ring material, available are high purity alumina ceramic to be coupled with carbon bearing and SiC coupled with SiC bearing. Wear resistant material of charged PTFE is employed for rear thrust material.

8. Gasket

ETFE enveloped gasket with non-asbestos core material is employed. PTFE gasket can resist virtually all chemical liquids.

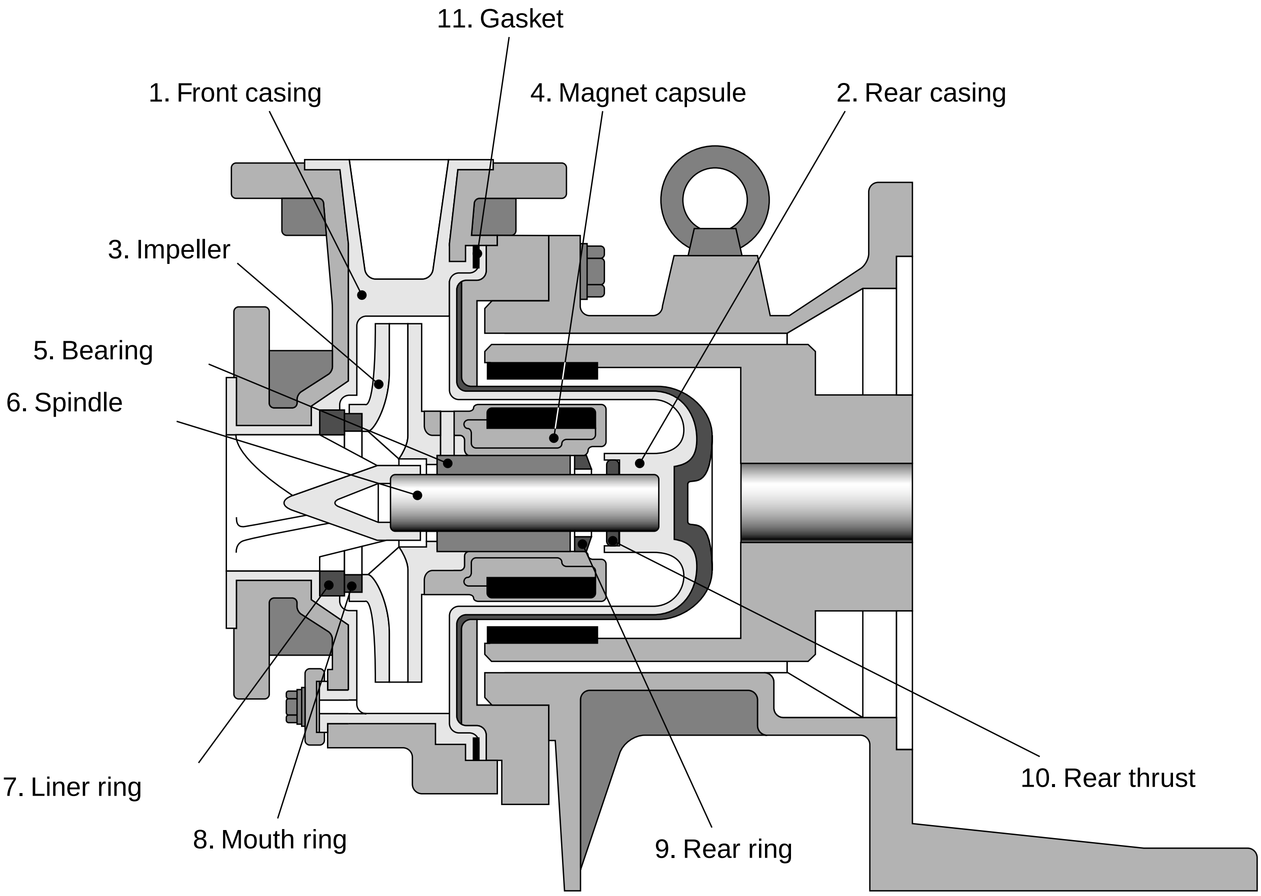
9. Foot support

The pump can be installed without common base because foot support is equipped with mounting foot. MDM pumps without baseplate models are interchangeable with IWAKI MDF- L pumps with regards to installation and piping and can be installed on the same base as MDF-L.

10. Common base

Common base is available for JIS and ISO Standards, which enable the piping conforming to respective standards.

2-2. Construction of wet-ends



2-3. Wet-ends material

<table>
<tr><th></th><th>Material code</th><th>ECF</th><th>EKK</th><th>PKK</th></tr>
<tr><td>1</td><td>Front casing</td><td colspan="2" rowspan="4">CFRETFE
(Carbon fiber reinforced ETFE)</td><td rowspan="4">PFA</td></tr>
<tr><td>2</td><td>Rear casing</td></tr>
<tr><td>3</td><td>Impeller</td></tr>
<tr><td>4</td><td>Magnet capsule</td></tr>
<tr><td>5</td><td>Bearing</td><td>High density carbon</td><td rowspan="5">SiC</td><td rowspan="5">SiC</td></tr>
<tr><td>6</td><td>Spindle</td><td rowspan="2">High purity alumina ceramic</td></tr>
<tr><td>7</td><td>Liner ring</td></tr>
<tr><td>8</td><td>Mouth ring</td><td>PTFE (filler charged)</td></tr>
<tr><td>9</td><td>Rear ring</td><td>High purity alumina ceramic</td></tr>
<tr><td>10</td><td>Rear thrust</td><td colspan="2">PTFE (filler charged)</td><td>PTFE</td></tr>
<tr><td>11</td><td>Gasket</td><td colspan="3">PTFE</td></tr>
</table>

2-4. Property of fluoro plastics

Property	ASTM method	Condition	Unit	PTFE	ETFE	PFA
Density	D792	—	—	2.13 - 2.22	1.7 - 1.76	2.12 - 2.17
Thermal conductivity	C177		cal/sec • cm • °C	6 x10^{-4}	5.7 x10^{-4}	—
Linear expansion coefficient	D696	23 - 60°C	1/°C	10 x10^{-5}	(5 - 9) x10^{-5}	12 x10^{-5} (+20 - +100°C)
Melting point	—	—	°C	327	260	302 - 310
Max. temp for continuous use				260	150	260
Tensile strength	D638	23°C	kgf/cm^2	140 - 350	410 - 470	280 - 315
Elongation			%	200 - 400	420 - 440	280 - 300
Compressive strength	D695	1%deform, 25°C	kgf/cm^2	50 - 60	109	50 - 60
Tensile elasticity	D638	23°C		4,000	5,000 - 8,000	—
Bending elasticity	D790			5,000 - 6,000	9,000 - 14,000	6,600 - 7,000
Impact strength	D256		ft-lb/in	3.0	No destruction	—
Hardness	—	Durometer	Shore	D50 - D65	D75	D60

(Note) Above figures are based on respective material manufacturer's data

2-5. Property of rubbing parts material

	Condition	Unit	SiC	Al_2O_3	High density carbon
Apparent density	—	—	3.0	3.8	1.88
Vickers hardness	Load 500g	kg/mm^2	HRA94	1650	ShoreD90
Bending strength(4-point bending for SiC and 3-point for Al_2O_3)	R.T.	kg/mm^2	50	30	10
	1000°C			18	—
	1400°C			—	
Young's modulus	R.T.	(x10^{-6})kg/mm^2	3.8	3.5	1300kg/mm^2
Poisson's ratio		—	0.16	0.25	0.2
Linear expansion coefficient	40 - 400°C	(x10^{-6})/°C	3.9	7.1	5.8
Thermal conductivity	R.T.	cal/sec • cm • °C	0.17	0.06	0.17
		W/m • K	71	25	70
Specific heat	R.T.	cal/g • °C	0.16	0.19	0.10
Thermal shock resistance temp	△T	°C	350	200	—

(Note) Above figures are based on respective material manufacturer's data

3. Standard specifications.

Model	Bore Inlet x Outlet	50Hz			60Hz			Motor output kW
		Impeller nominal diameter	Disch. capacity L/min.	Head m	Impeller nominal diameter	Disch. capacity L/min.	Head m	
MDM25-1 (Impeller range 1)	40A x 25A	165	100	36.0	140	100	36.0	1.5, 2.2
		160		34.0	130		30.5	
		150		29.5	120		25.0	
		140		25.5	110		20.5	
		130		21.0	100		15.5	
MDM25-2 (Impeller range 2) ETFE type	40A x 25A	195	100	51.5	170	100	54.5	3.7, 5.5, 7.5
		190		49.0	160		48.5	
		180		44.5	150		42.5	
		170		39.0	140		36.5	
		160		34.5	130		30.5	
MDM25-2 (Impeller range 2) PFA type	40A x 25A	195	100	50.5	170	100	53.5	3.7, 5.5, 7.5
		190		47.5	160		48.0	
		180		42.0	150		40.5	
		170		37.0	140		34.0	
		160		33.0	130		28.5	
MDM40	50A x 40A	165	208	35.0	145	250	39.5	3.7, 5.5, 7.5
		160		32.5	140		36.5	
		150		29.5	130		28.5	
		140		25.5	120		25.5	
		130		21.5	110		20.5	
		120		17.5	—	—	—	
MDM50	65A x 50A	165	417	33.0	160	500	44.5	3.7, 5.5, 7.5
		160		32.5	150		39.0	
		150		28.0	140		33.0	
		140		23.5	130		27.0	
		130		18.0	120		21.0	
		120		15.0	110		18.0	
		110		11.0	—	—	—	
MDM65	80A x 65A	165	833	39.0	160	1000	51.0	5.5, 7.5, 11 15(for 60Hz only)
		160		35.5	150		43.5	
		150		31.0	140		36.5	
		140		25.0	130		31.0	
		130		21.0	120		25.5	
		120		17.0	110		20.0	
		110		13.5	—	—	—	

Common specifications:

1. Standard motor: 2-pole, 3-phase, TEFC, Outdoor, Flange mount made by HITACHI
2. Standard painting: RAL 5002 (Ultra marine blue)

4.Conditions to be used

1. Liquid temperature range ETFE material type: 0 - 105˚C
   PFA material type: 0 - 120˚C
2. Slurry containing liquid (KK type only)
   Slurry concentration: 5wt% or less, Hardness: 80Hs or less, Solid size: 50μm or less.
   (Note) Figures are for referense but not guarantee.
3. Max. pump pressure: 1.0MPa

5. Model code

MDM 50 - 150 1 E KK F 055 J - D 2

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

① Pump discharge bore (Suction x Discharge)

25 : 40A x 25A, 40 : 50A x 40A, 50 : 65A x 50A, 65 : 80A x 65A

② Nominal impeller diameter

100 - 195 (mm)

③ Impeller range

1 : For low head impeller range

2 : For high head impeller range (For MDM25 only)

④ Casing material

E : CFRETFE

P: PFA

⑤ Bearing/spindle material

KK : SiC/SiC

CF : High density carbon/High purity alumina ceramic

⑥ Type of motor to be mounted

F : Flange mounted motor type

⑦ Motor output

015 : 1.5kW, 022 : 2.2kW, 037 : 3.7kW, 055 : 5.5kW,

075 : 7.5kW, 110 : 11kW, 150 : 15kW

⑧ Standard for connection flange/motor

J : JIS flange + JIS motor

I : ISO flange + IEC motor

⑨ Drain/special version

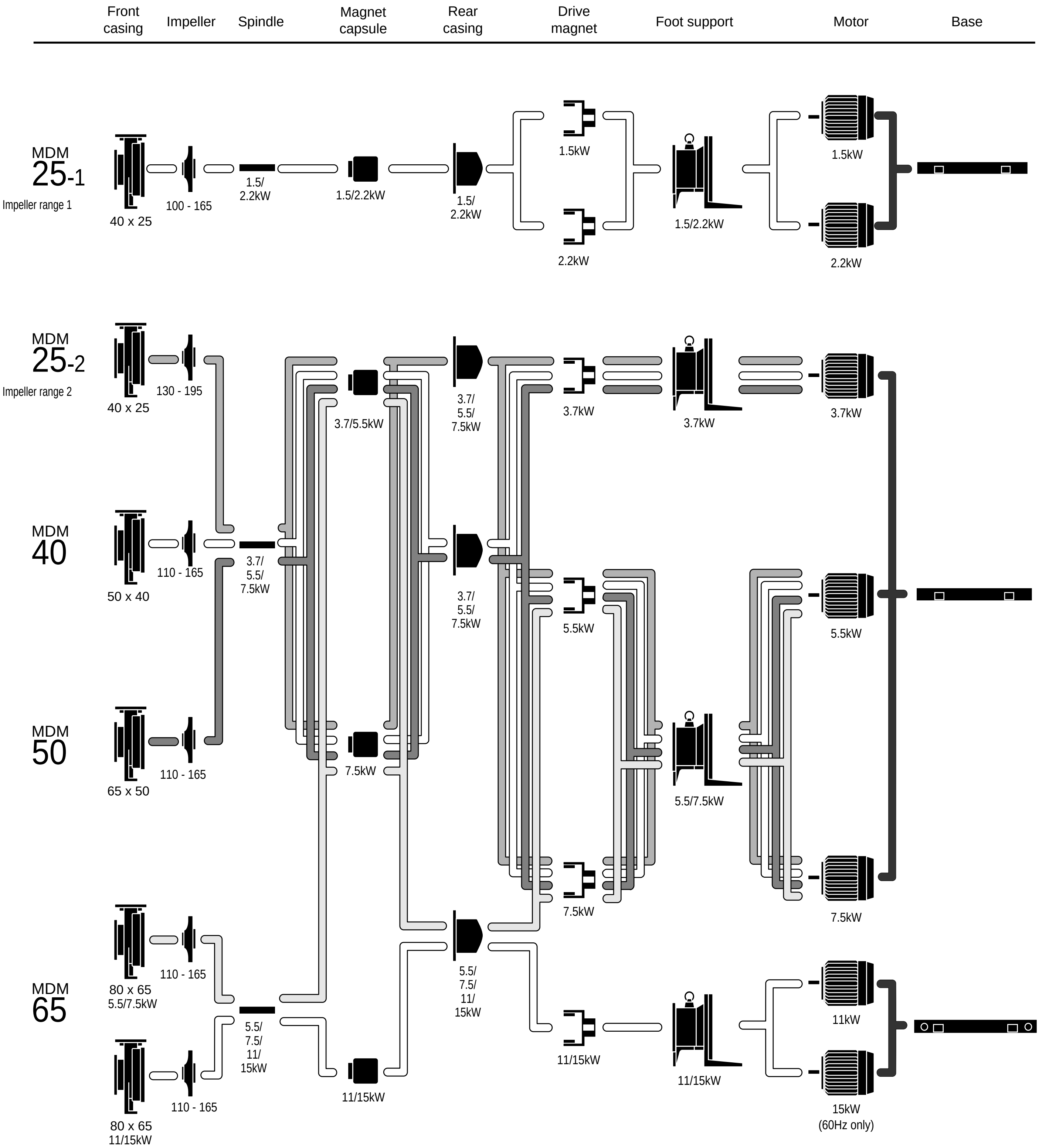
	Drain	Baseplate	Standard or Special version
A	Without drain	With baseplate	Standard
S			Special version
D	With drain		Standard
X			Special version
B	Without drain	Without baseplate	Standard
Y			Special version
E	With drain		Standard
Z			Special version

(Note) For PFA material type, air vent is always equipped for "with drain" type.

⑩ No. of motor pole

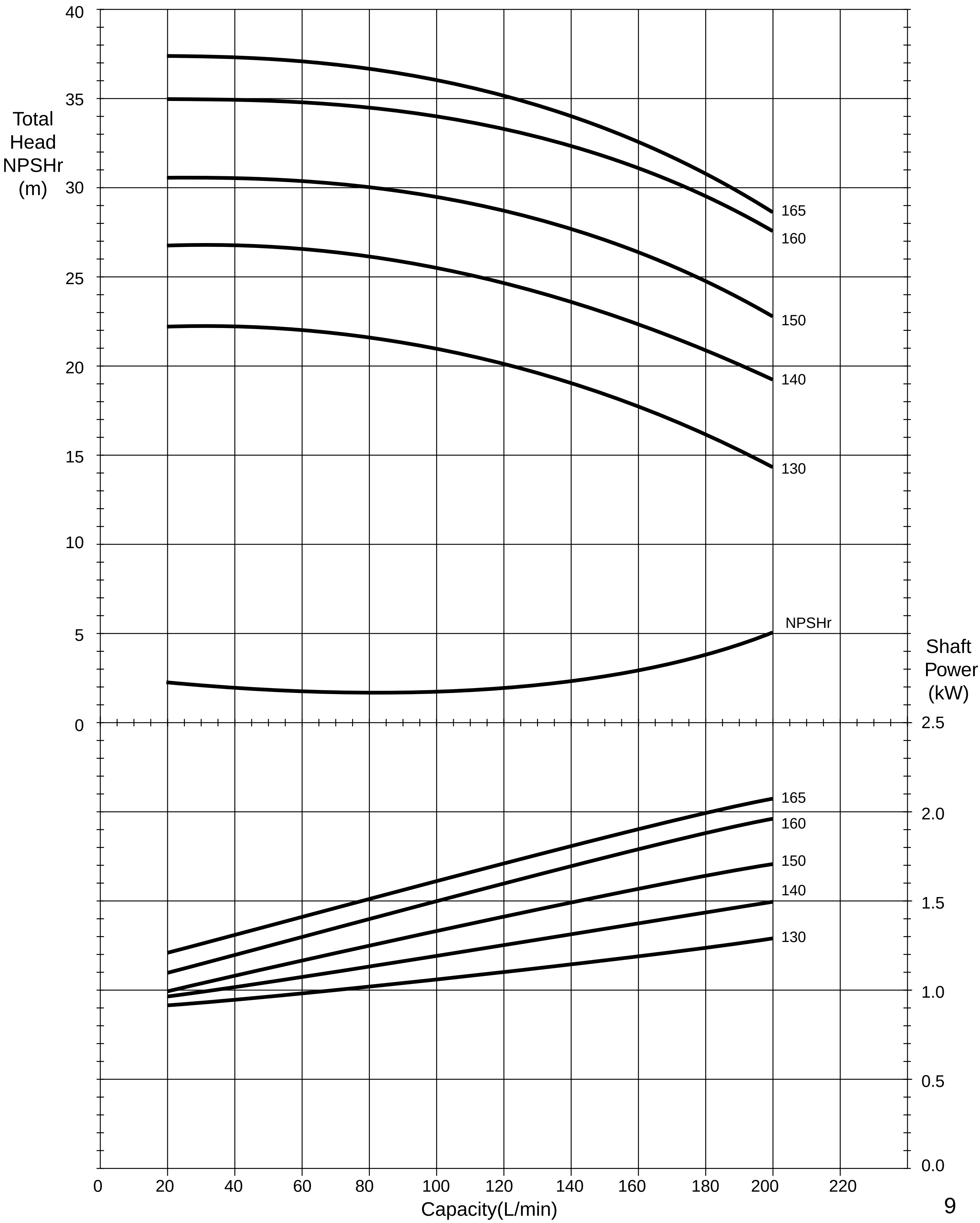
2 : 2 pole motor

6. Modular construction

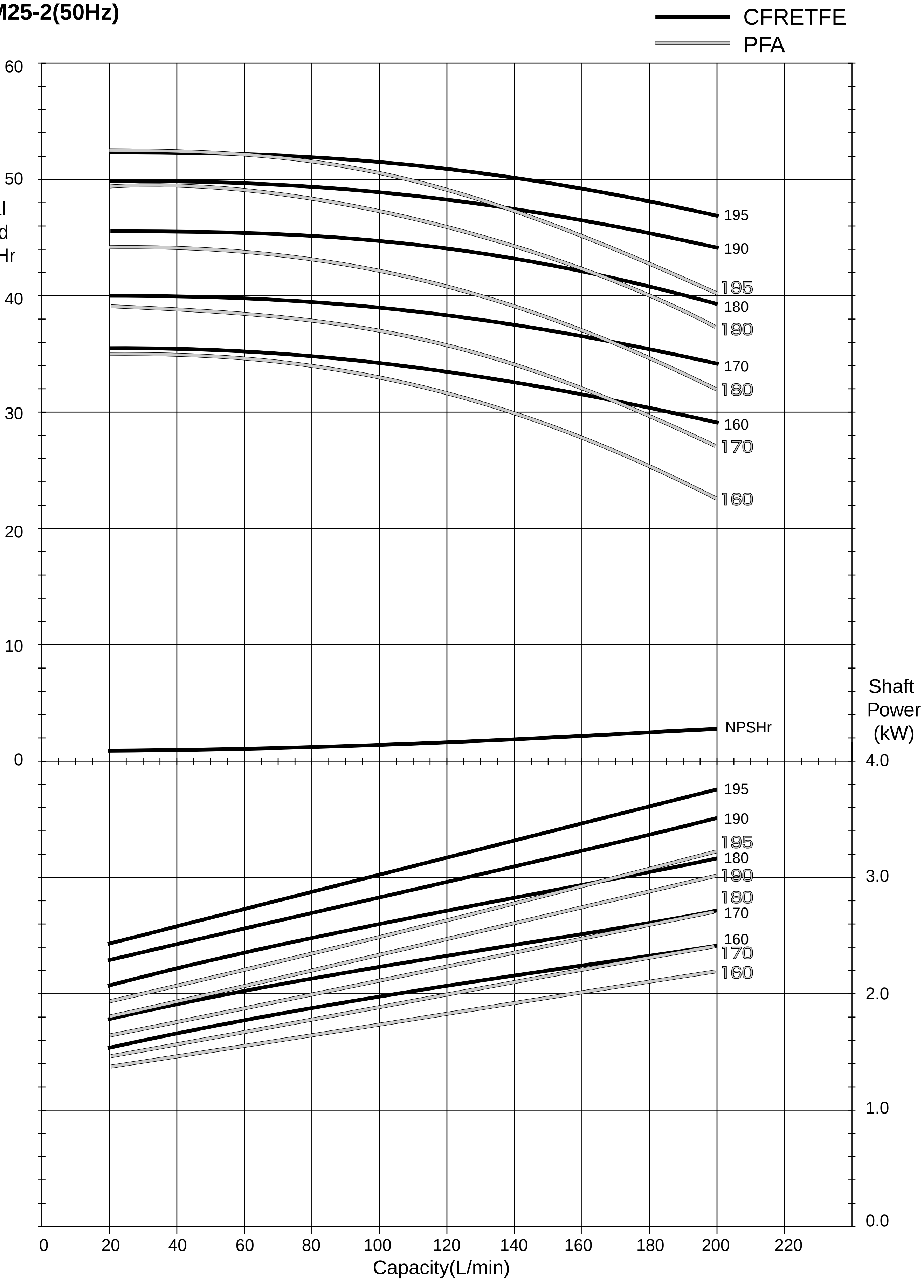


7. Perfomance curves

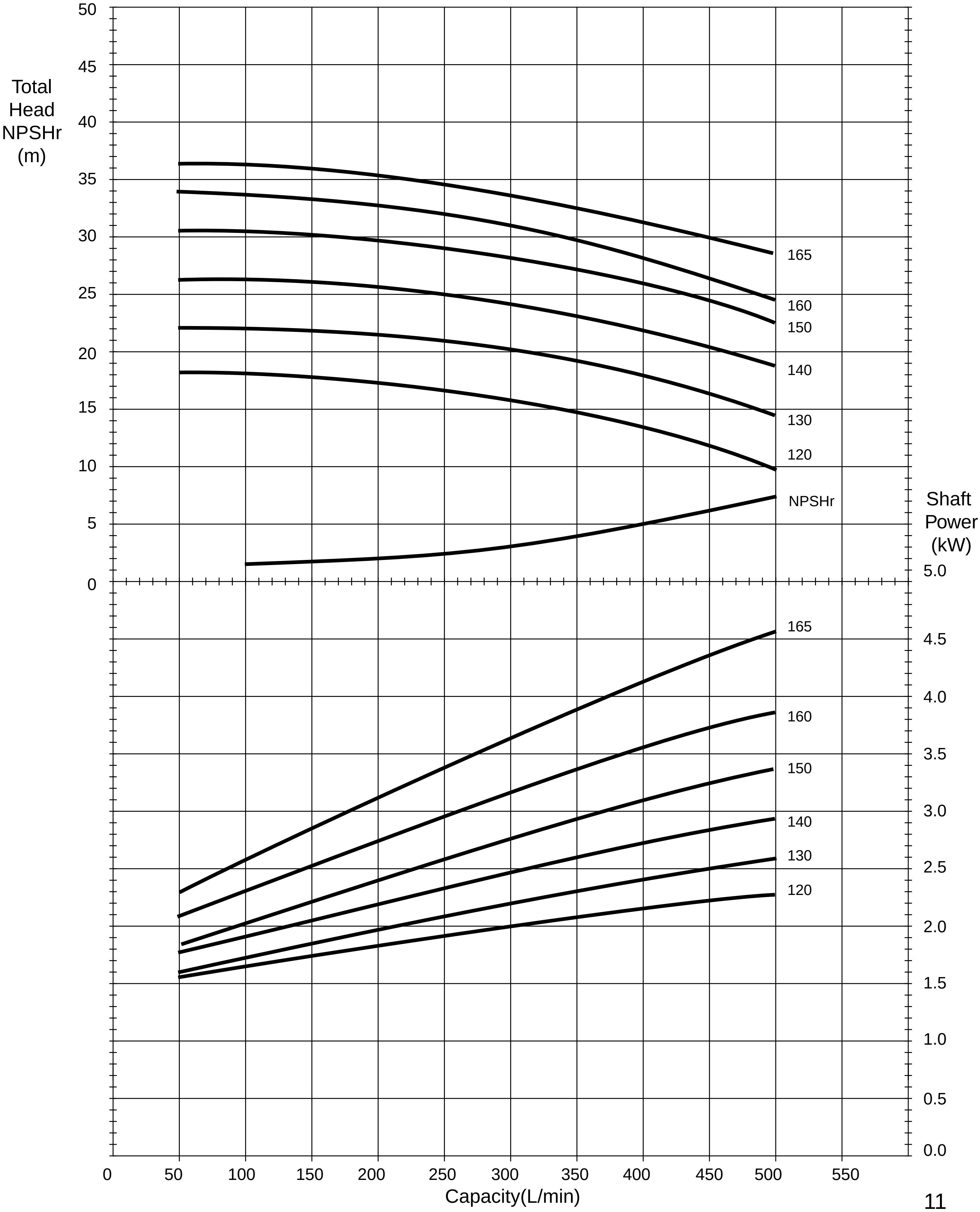
MDM25-1(50Hz)



MDM25-2(50Hz)

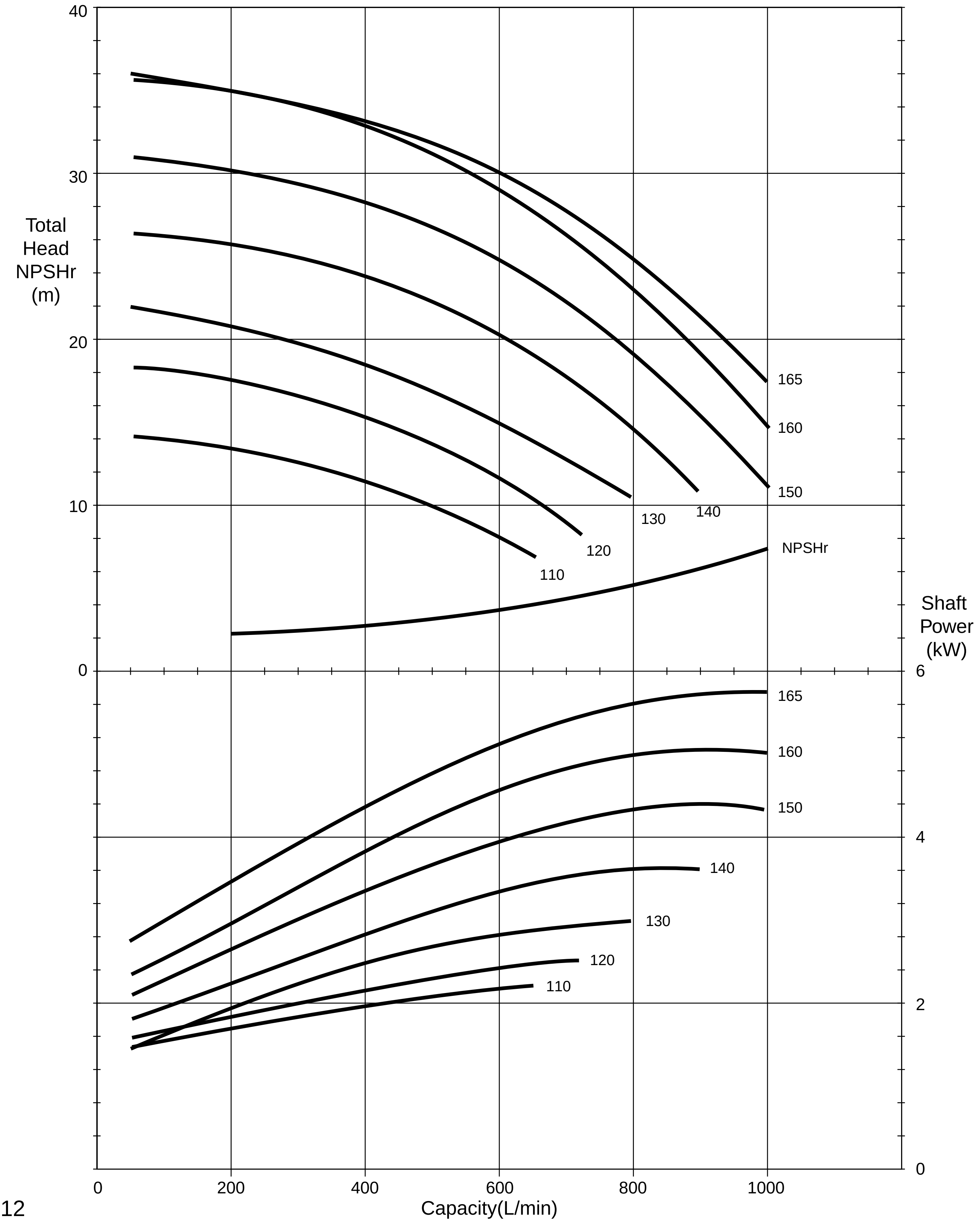

CFRETFE
PFA
Total Head NPSHr (m)
60
50
40
30
20
10
0
195
190
180
170
160
NPSHr
Shaft Power (kW)
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
140
160
180
200
220
Capacity(L/min)

MDM40(50Hz)

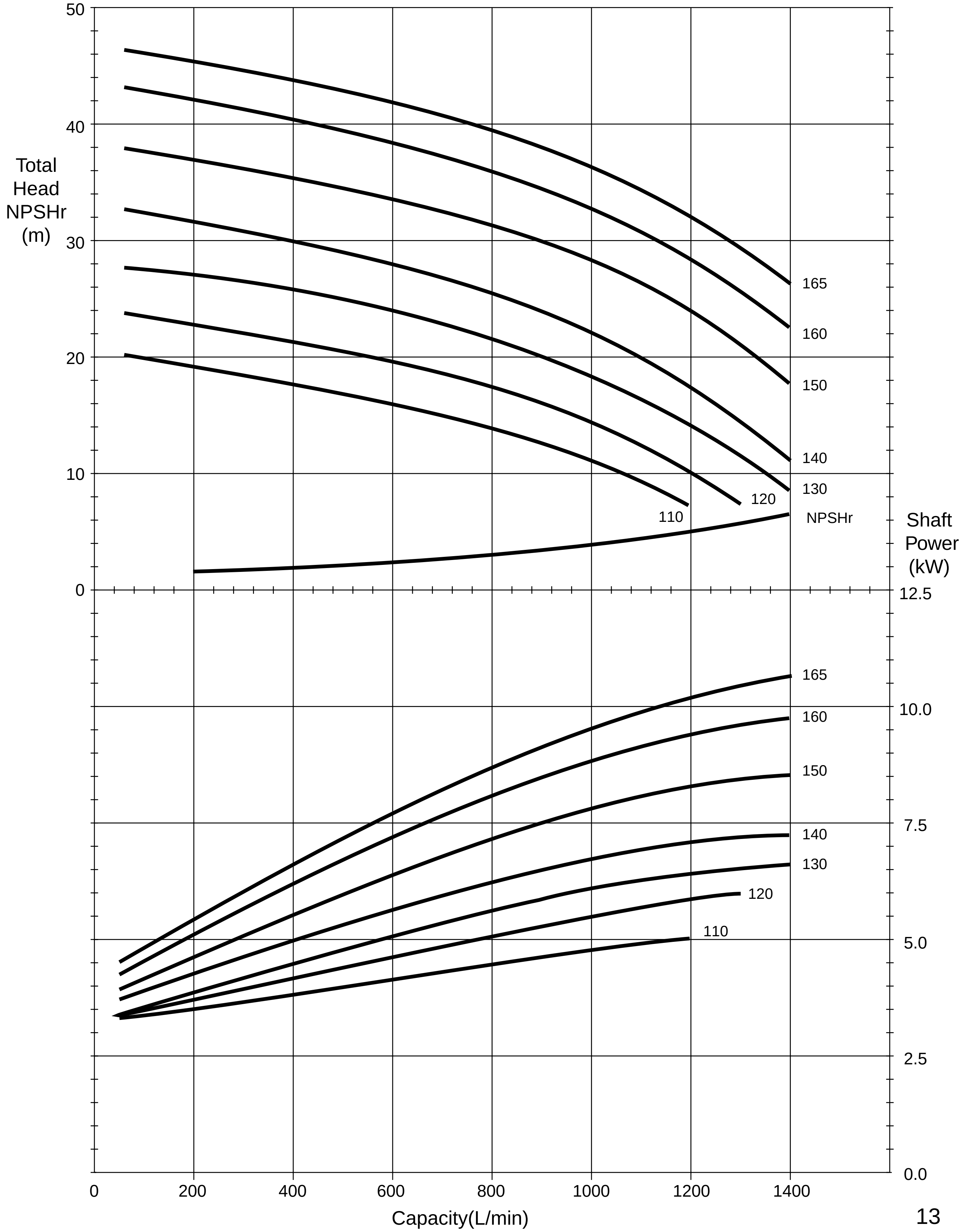


Total
Head
NPSHr
(m)
50
45
40
35
30
25
20
15
10
5
0
165
160
150
140
130
120
NPSHr
Shaft
Power
(kW)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
165
160
150
140
130
120
0
50
100
150
200
250
300
350
400
450
500
550
Capacity(L/min)

MDM50(50Hz)

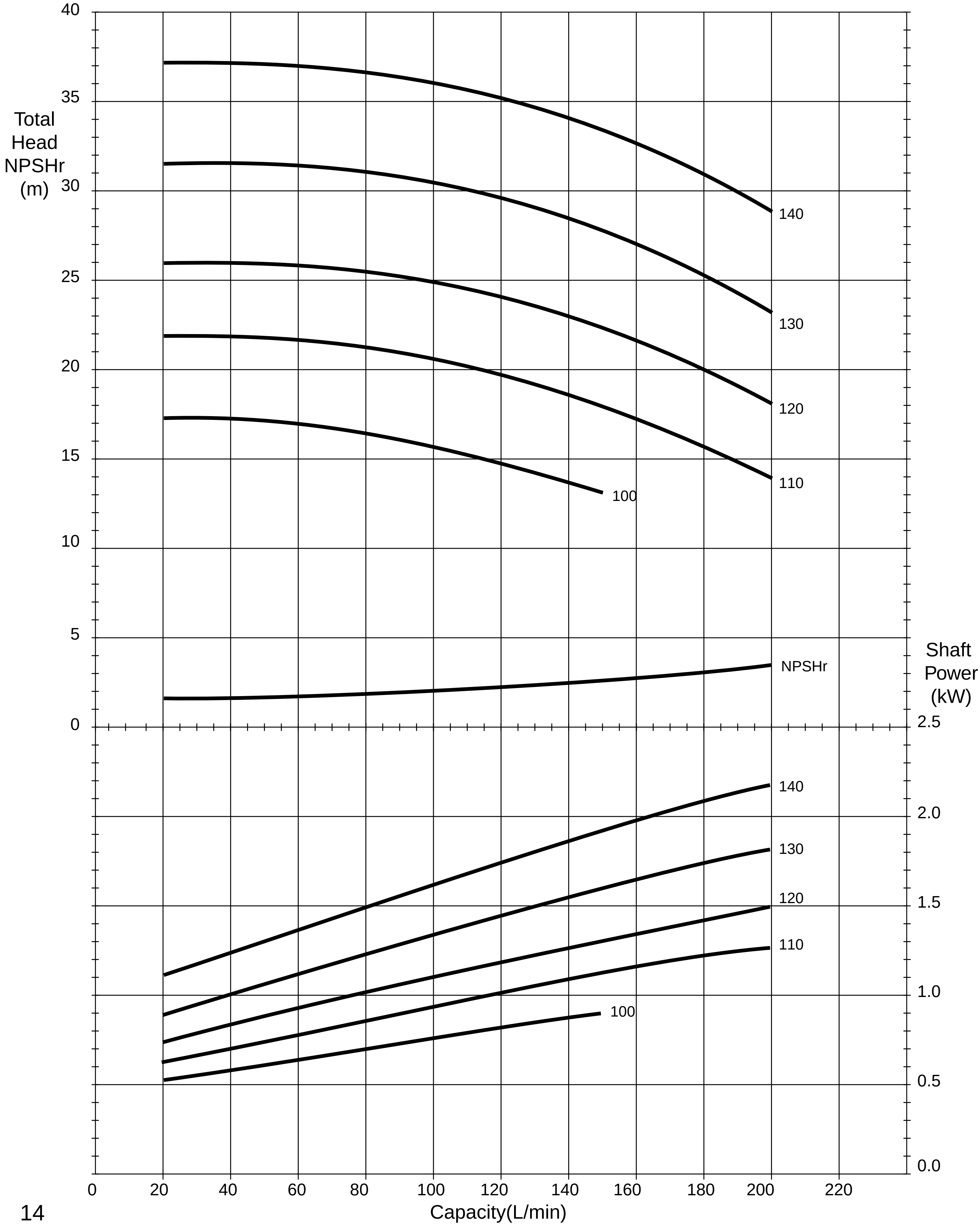

40
30
20
10
0
Total
Head
NPSHr
(m)
165
160
150
140
130
120
110
NPSHr
Shaft
Power
(kW)
6
4
2
0
165
160
150
140
130
120
110
0
200
400
600
800
1000
Capacity(L/min)

MDM65(50Hz)

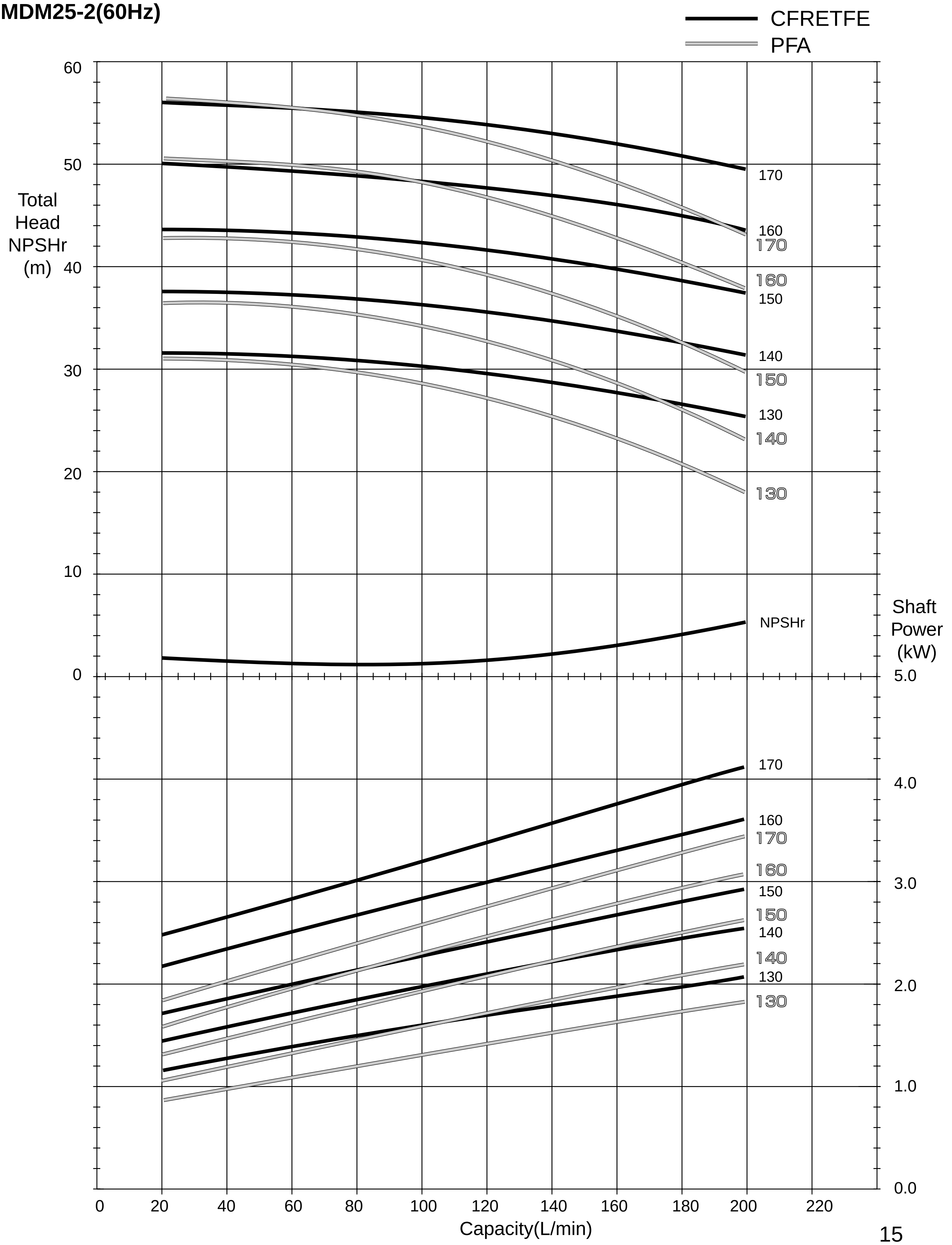


50
40
30
20
10
0
Total
Head
NPSHr
(m)
165
160
150
140
130
120
110
NPSHr
Shaft
Power
(kW)
12.5
10.0
7.5
5.0
2.5
0.0
165
160
150
140
130
120
110
0
200
400
600
800
1000
1200
1400
Capacity(L/min)

MDM25-1(60Hz)

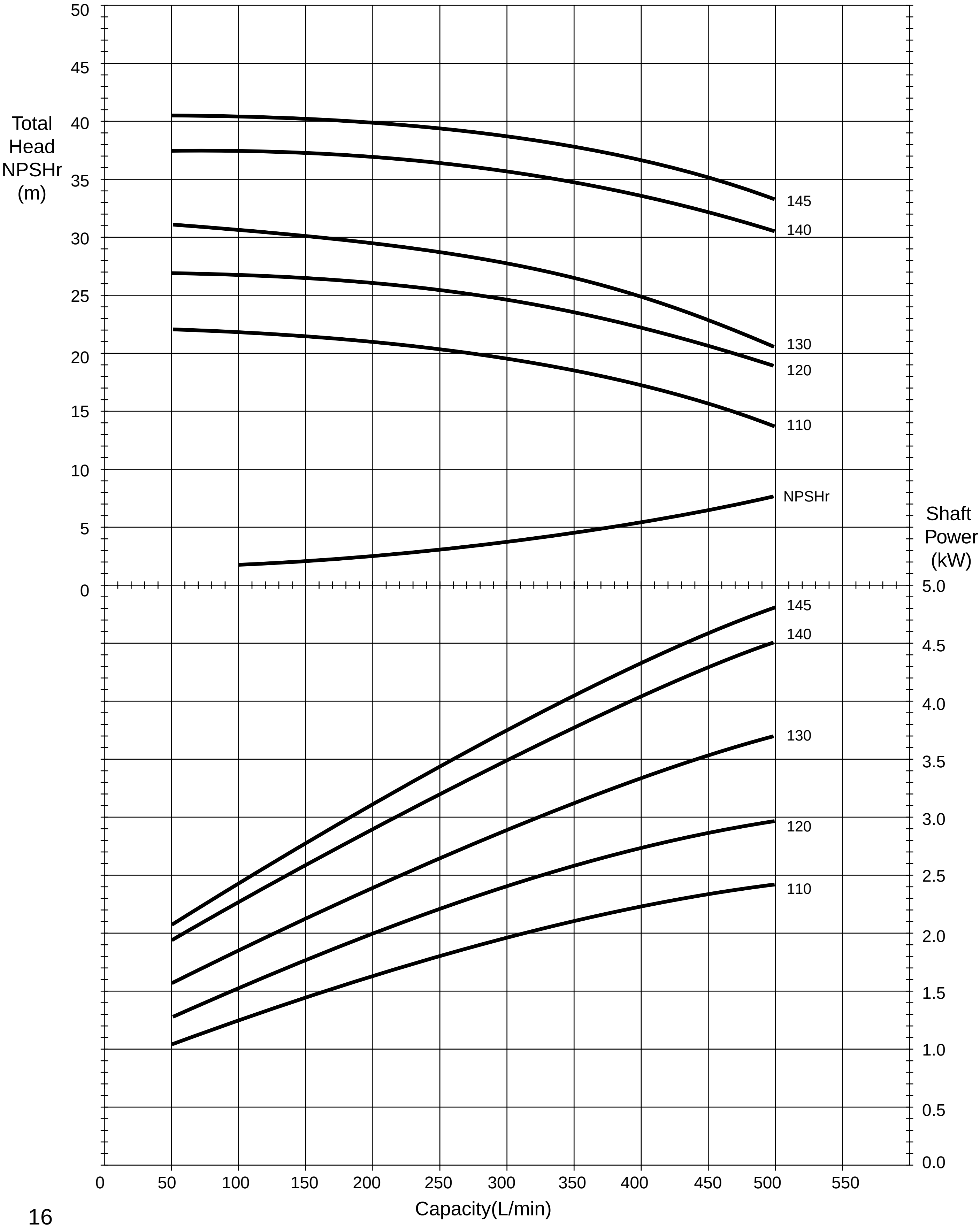

Total
Head
NPSHr
(m)
40
35
30
25
20
15
10
5
0
140
130
120
110
100
NPSHr
Shaft
Power
(kW)
2.5
2.0
1.5
1.0
0.5
0.0
140
130
120
110
100
0
20
40
60
80
100
120
140
160
180
200
220
Capacity(L/min)

MDM25-2(60Hz)



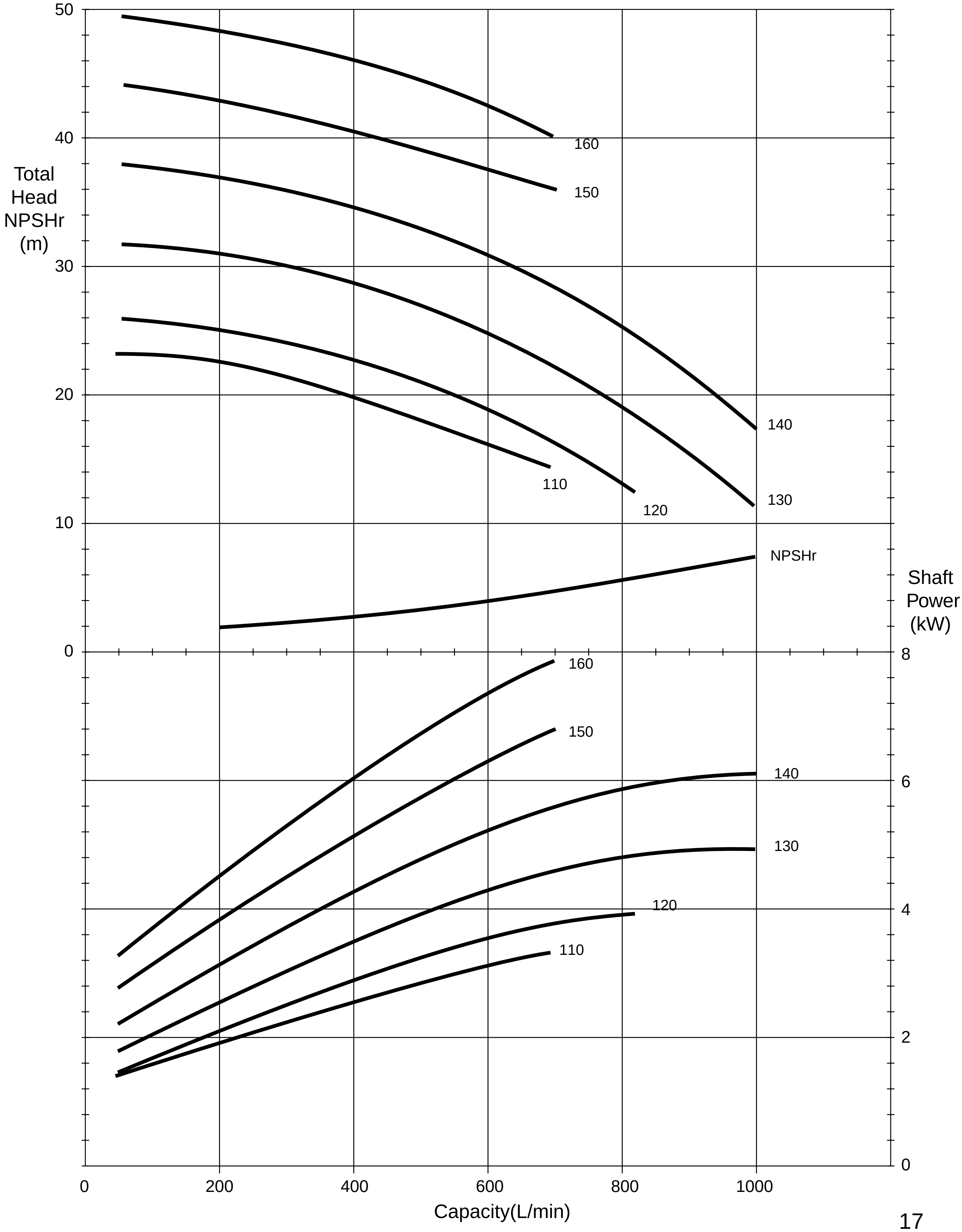
CFRETFE
PFA
Total Head NPSHr (m)
60
50
40
30
20
10
0
170
160
170
160
150
150
140
140
130
130
NPSHr
Shaft Power (kW)
5.0
4.0
3.0
2.0
1.0
0.0
170
160
170
160
150
150
140
140
130
130
0
20
40
60
80
100
120
140
160
180
200
220
Capacity(L/min)

MDM40(60Hz)

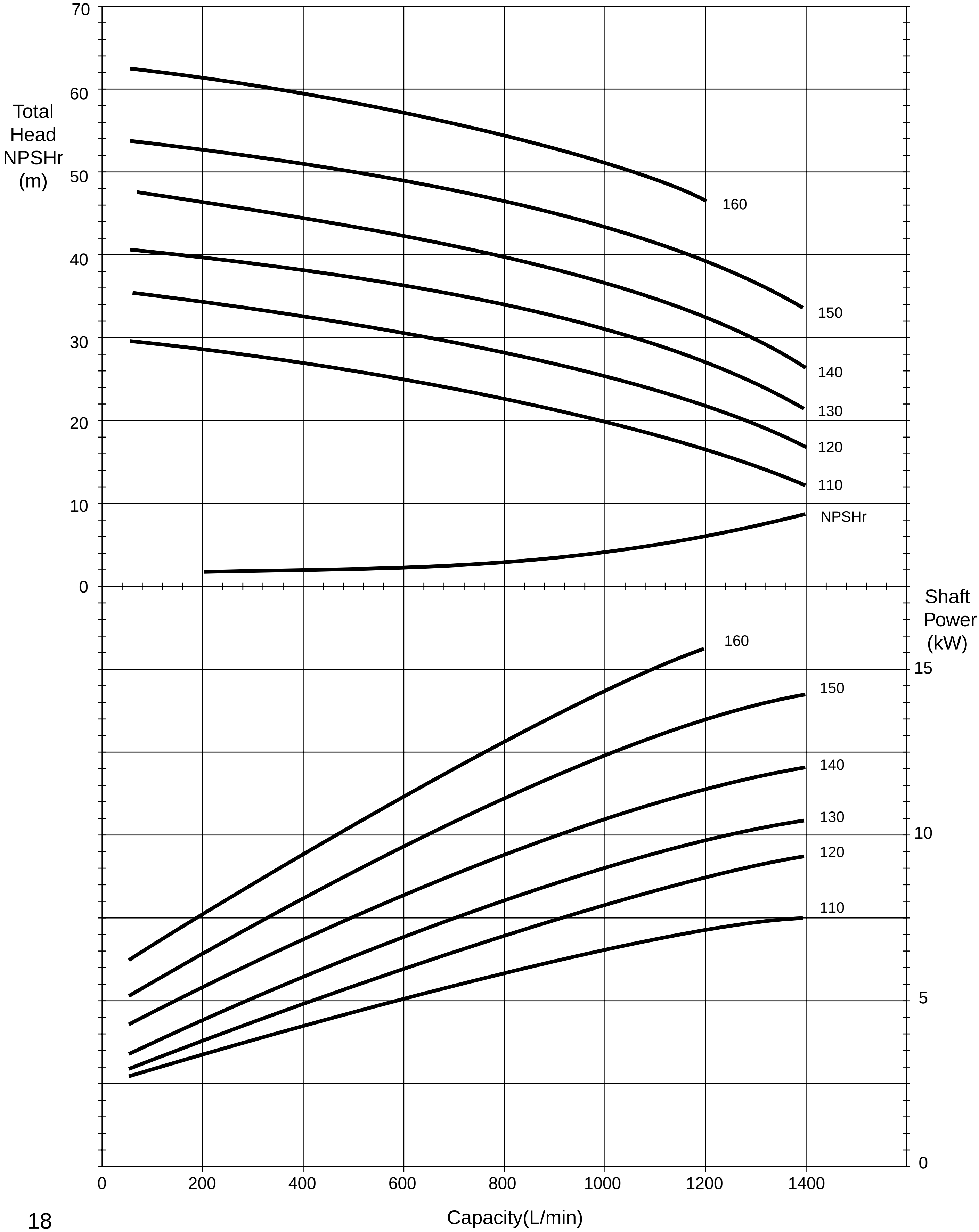


Total Head NPSHr (m)
50
45
40
35
30
25
20
15
10
5
0
145
140
130
120
110
NPSHr
Shaft Power (kW)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
145
140
130
120
110
0
50
100
150
200
250
300
350
400
450
500
550
Capacity(L/min)

MDM50(60Hz)


50
40
30
20
10
0
Total
Head
NPSHr
(m)
160
150
140
130
120
110
NPSHr
Shaft
Power
(kW)
8
6
4
2
0
160
150
140
130
120
110
0
200
400
600
800
1000
Capacity(L/min)

MDM65(60Hz)



70
60
50
40
30
20
10
0
Total Head NPSHr (m)
160
150
140
130
120
110
NPSHr
Shaft Power (kW)
15
10
5
0
0
200
400
600
800
1000
1200
1400
Capacity(L/min)

8.Selection of pump model

8-1. Selection procedure

1. Planned discharge capacity

Decide normal and maximum discharge capacity.

2.Calculation of total head

Calculation of actual head. Calculation of pipe resistance.

(Refer to following pipe resistant graph and equivalent straight pipe length.)

3. Provisional decision of pump model

Referring to attached performance curves, provisionally decide pump bore(model).

4. Examination of NPSH

Calculation of NPSHa. To know NPSHr from H-Q curves.

5. Calculation of shaft power

Provisionally decide shaft power according to H-Q curves.

In case specific gravity of liquid is other than 1 (viscosity is same as water), get the shaft power by multiplying the power which is required when pumping water.

For viscous liquid (more than 10mPa•s), performance compensation is needed according to item 8-6.

6. Performance compensation

In case the liquid is viscous (more than 10mPa•s), compensation must be done,

If it affects the discharge capacity and head, re-examine once again from above item 1 to finally decide the pump model.

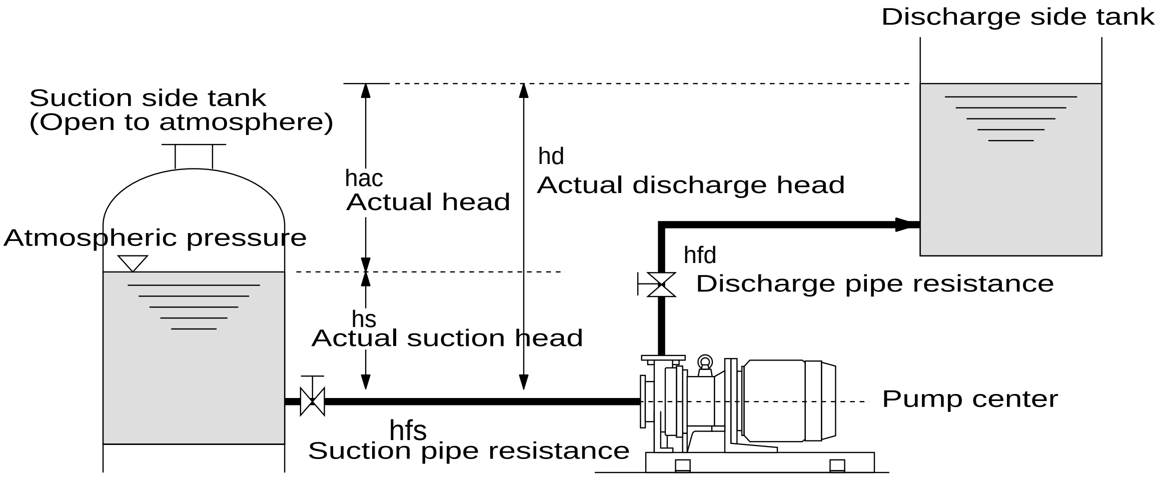
8-2. Calculation of total head

In case of open system

Total head "Ht" = Actual head " hac" + Pipe resistance "hf"

=Actual discharge head"hd" -Actual suction head"hs"+Pipe resistance "hf" (hf=hfs+hfd)

$$hf= f \cdot \frac{L}{D} \cdot \frac{V^2}{2g} \quad \text{(Darcy formula)} \quad m$$



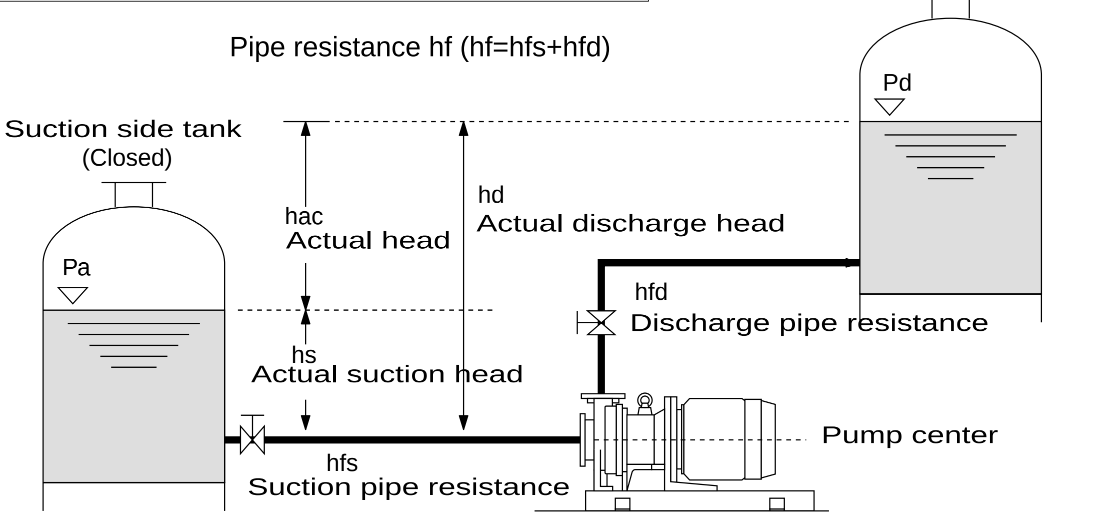
f : 0.020+0.0005/D (New pipe)
v : Velocity in pipe m/sec
L : Pipe length m
hac : Actual head m

D : Pipe inside dia. m
g : Gravitational constant $9.8 m/sec^2$
hf : Pipe resistance m

In case of closed system

$$\text{Total head "Ht"} = \frac{10^6 \text{ (Pd-Pa)}}{\rho g} + hac + hf \quad m$$

Pipe resistance hf (hf=hfs+hfd)

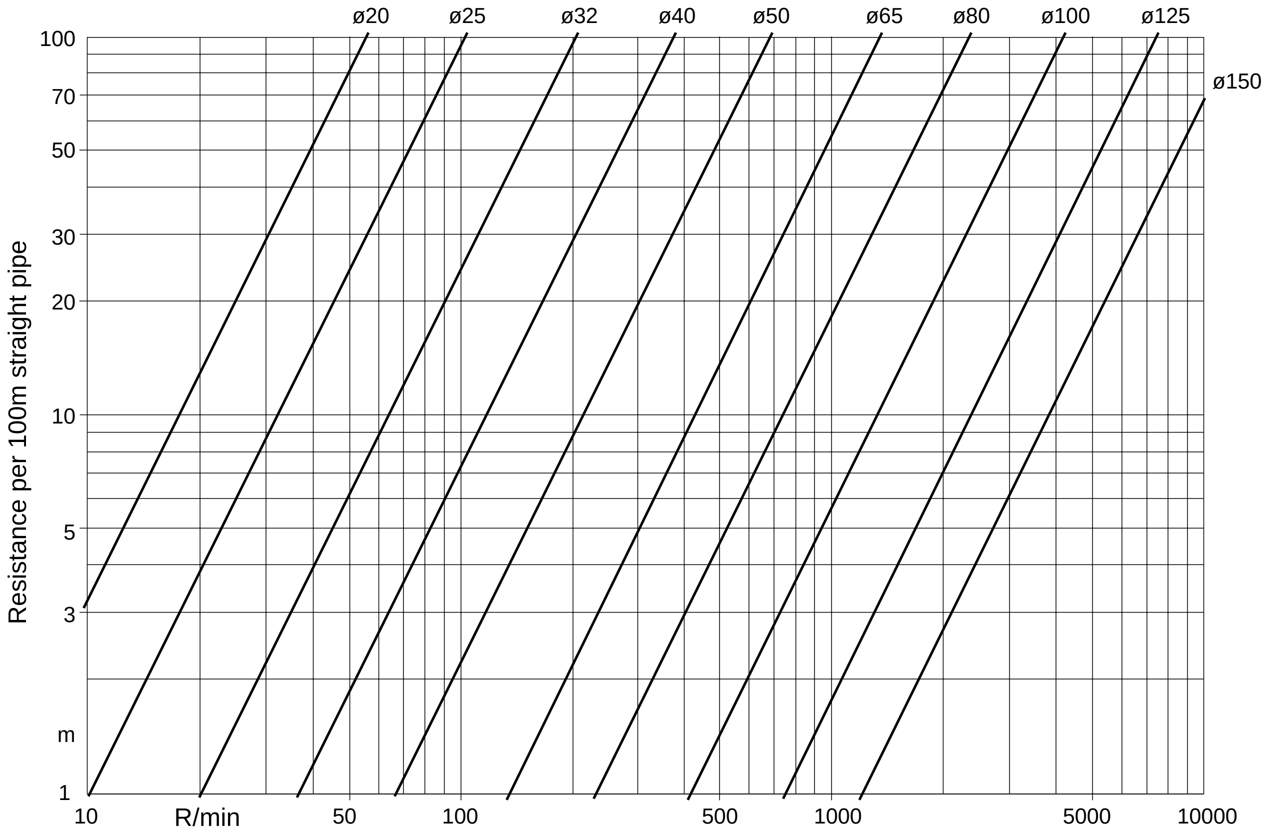


Pa : Absolute pressure put on liquid surface of suction side tank MPa
Pd : Absolute pressure put on liquid surface of discharge side tank MPa
hac : Actual head m

hf : Pipe resistance m
ρ : Density of liquid kg/m^3
g : Gravitational constant $9.8 m/sec^2$

8-3. Piping resistance

Friction loss of straight pipe



Equivalent straght pipe length of fittings

Fittings			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
Regualr 90° elbow		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
Long redius 90° elbow		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
Regualr 45° elbow		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
Tee-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
Tee-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
180° Return bend		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
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	123.5	28.6	36.5	45.6	57.8
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
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
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
Union		Screwed	0.07	0.09	0.1	0.1	0.1	0.1	0.1	0.2		
Bell-mouth inlet			0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5
Square mouth inlet			0.4	0.6	0.8	0.9	1.3	1.6	2.0	2.9	4.0	4.9
Re-entrance			0.8	1.1	1.5	1.9	2.6	3.0	4.0	4.8	7.6	9.7

8-4. Examination of suction conditions (NPSH)

NPSH means the net positive head worked at pump inlet port. That is the figure indicated in meter of the degree of energy which coveys the liquid toward the pump inlet port. If NPSH figure is small, the cavitation will occur in the pump resulting in vibration, noise and break down of pump. If NPSH is further smaller, the pump can not suck well the liquid and can not do the pumping operation.

Cavitation

If there is a place inside the pump where the pressure is lower than vapor pressure of the liquid, the liquid is vaporized there. This is the cavitation phenomenon. Inlet port of the impeller is the place where the lowest pressure is brought in the pump. If liquid pressure gets lower than the vapor pressure at the temperature of the liquid, the liquid is instantly vaporized and generates bubbles at the inlet port of impeller. Then the liquid moves to the periphery of impeller where the pressure is high and the bubbles are instantly pressed. This shock generates abnormal vibration and noise and resulting in break down of the part around the impeller. If the suction condition becomes worse, the pump can not suck the liquid.

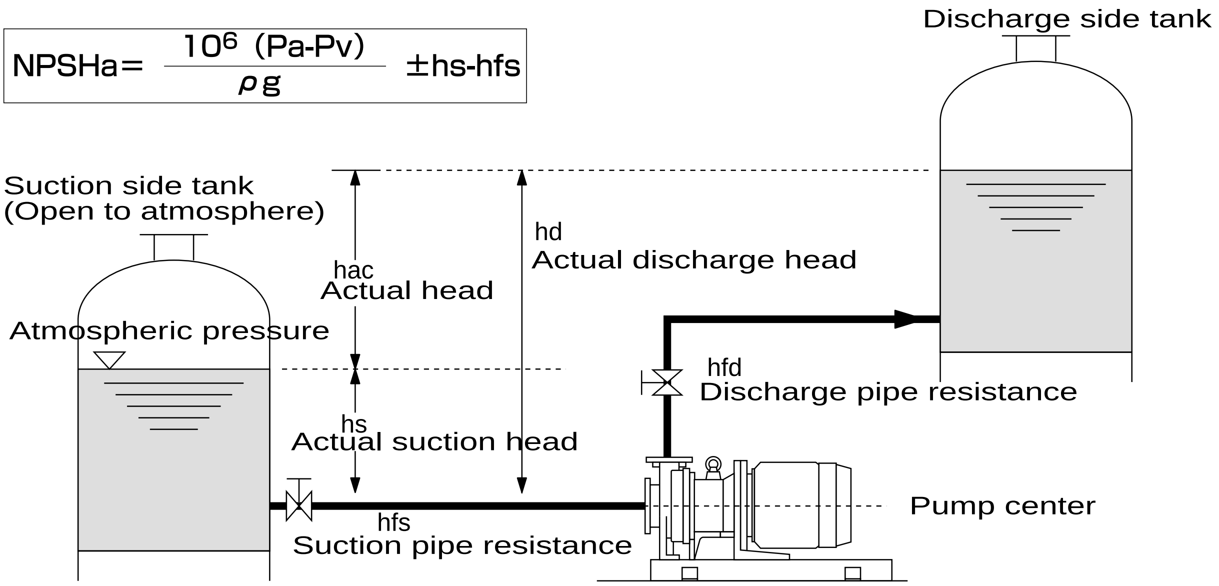
1. Condition for the pump not to generate the cavitation

$$NPSHa \geqq NPSHr + 0.5m$$

NPSHa : Available NPSH m
NPSHr : Required NPSH (shown in performance curve) m
0.5 m : Allowance

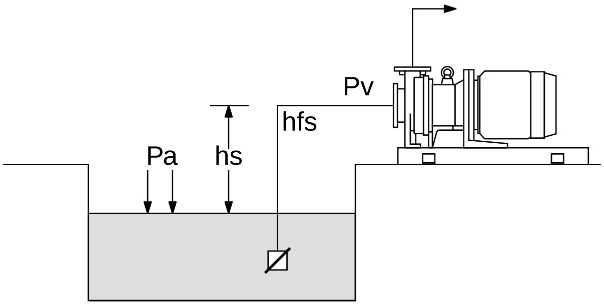
2. How to get NPSHa

$$NPSHa = \frac{10^6\ (Pa-Pv)}{\rho g} \pm hs-hfs$$



Pa : Absolute pressure put on liquid surface of suction side tank (If opened to atmosphere, it is atmospheric pressure : Normally 1 atm = 0.1013 MPa) MPa
Pv : Vapor pressure of liquid at temperature of pump inlet MPa
hs : Height from liquid surface of suction side tank to the center of pump inlet port m
hfs: Suction side pipe resistance m
ρ : Density of liquid kg/m^3
g : Gravitational acceleration $9.8m/sec^2$

3. In case of suction lift



$$NPSHa = \frac{10^6 \ (Pa\text{-}Pv)}{\rho g} - hs - hfs \qquad m$$

Pa : Absolute pressure put on liquid surface of suction side tank (If opened to atmosphere, it is atmospheric pressure : Normally 1 atm = 0.1013 MPa) MPa

Pv : Vapor pressure of liquid at temperature of pump inlet MPa

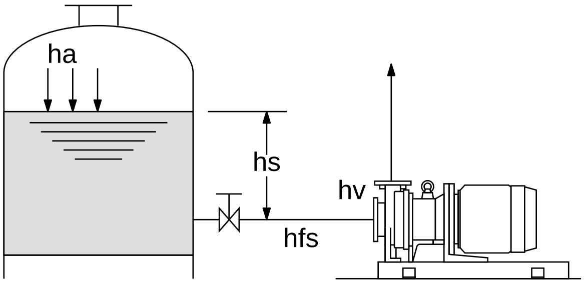
hs : Height from liquid surface of suction side tank to the center of pump inlet port m

hfs: Suction side pipe resistance m

ρ : Density of liquid kg/m^3

g : Gravitational acceleration $9.8m/sec^2$

4. In case of flooded suction



$$NPSHa = \frac{10^6 \ (Pa\text{-}Pv)}{\rho g} + hs - hfs$$

Pa : Absolute pressure put on liquid surface of suction side tank (If opened to atmosphere, it is atmospheric pressure : Normally 1 atm = 0.1013 MPa) MPa

Pv : Vapor pressure of liquid at temperature of pump inlet MPa

hs : Height from liquid surface of suction side tank to the center of pump inlet port m

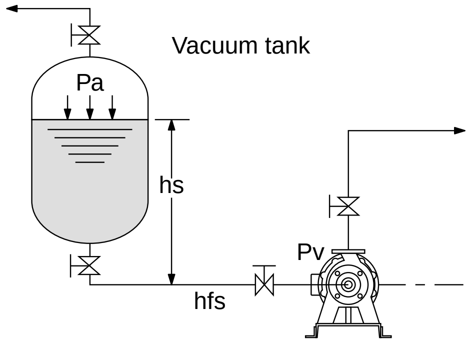
hfs: Suction side pipe resistance m

ρ: Density of liquid kg/m^3

g : Gravitational acceleration $9.8m/sec^2$

5. In case of vacuum tank

$$\text{NPSHa} = \frac{10^6\,(\text{Pa}-\text{Pv})}{\rho g} + \text{hs} - \text{hfs} \quad \text{m}$$

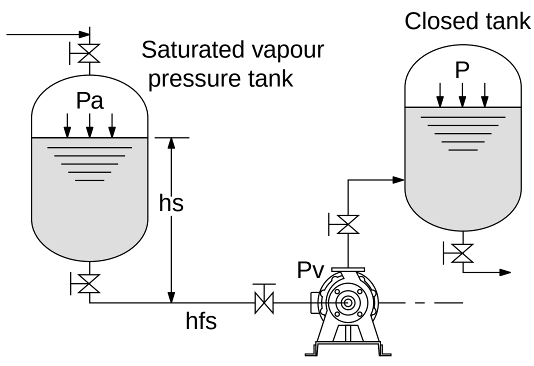


Pa : Absolute pressure put on liquid surface of suction side tank MPa
Pv : Vapor pressure of liquid at temperature of pump inlet MPa
hs : Height from liquid surface of suction side tank to the center of pump inlet port m
hfs: Suction side pipe resistance m
ρ: Density of liquid kg/m^3
g : Gravitational acceleration $9.8 m/sec^2$

6. In case of saturated vapor pressure tank

$$\text{NPSHa} = \frac{10^6\,(\text{Pa}-\text{Pv})}{\rho g} + \text{hs} - \text{hfs} \qquad \text{here, Pa} = \text{Pv}$$

$$\text{NPSHa} = \text{hs} - \text{hfs} \quad \text{m}$$



Pa : Absolute pressure put on liquid surface of suction side tank MPa
Pv : Vapor pressure of liquid at temperature of pump inlet MPa
hs : Height from liquid surface of suction side tank to the center of pump inlet port m
hfs: Suction side pipe resistance m
ρ: Density of liquid kg/m^3
g : Gravitational acceleration $9.8 m/sec^2$

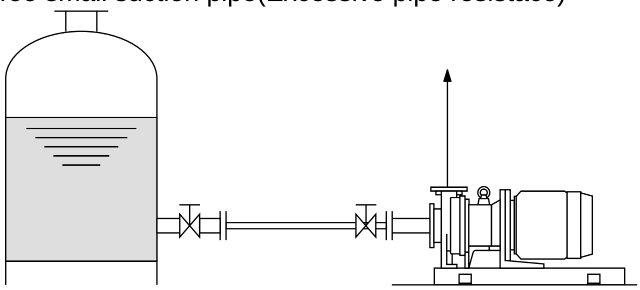
Countermeasure in case of shortage of NPSHa value

Causes of shortage of NPSHa value	Countermeasure
Too low flooded suction height (hs) (Too high suction lift height)	Lower liquid level of tank Lower pump installed level
Too large suction pipe resistance (hfs)	Use larger, shorter & straight piping Change to pipe or valve of smaller resistance
Too low pressure (Pa) on liquid surfa- ce 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 (Pv)	Lower liquid temp. at pump inlet to lower vapor pressure

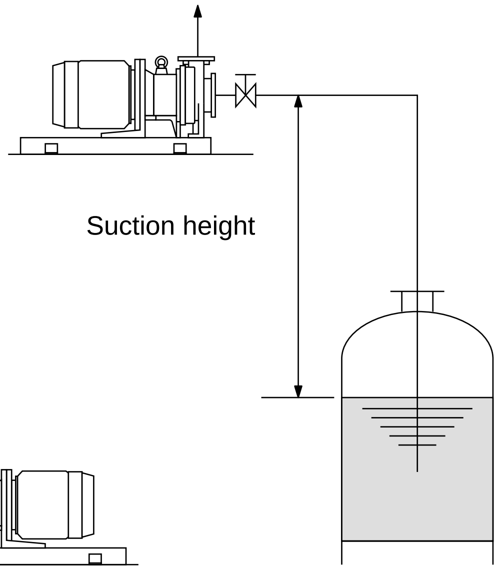
It may be possible to select the pump which has lower NPSHr value by selecting, for example, the pump model of one step larger one.

Examples of piping which may cause cavitation

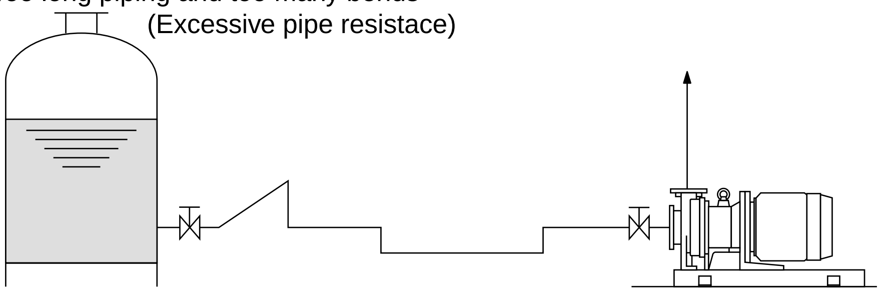
Too small suction pipe(Excessive pipe resistace)



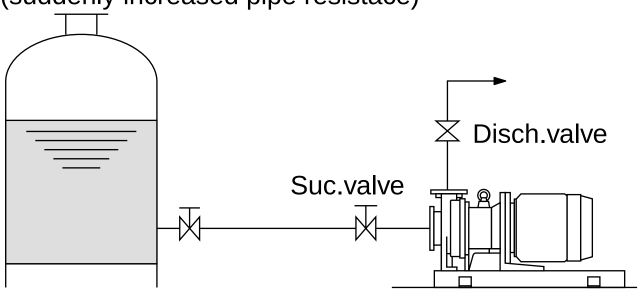
Too high suction lift



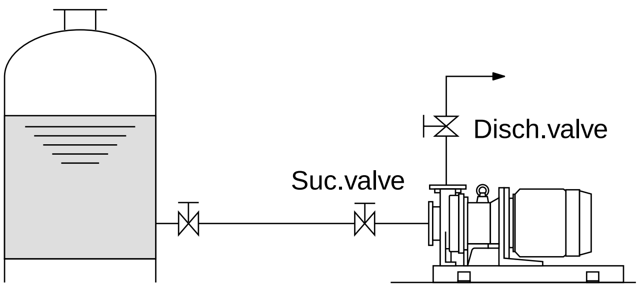
Too long piping and too many bends
(Excessive pipe resistace)



Closed suction valve
(suddenly increased pipe resistace)



Fully opened discharge valve(Increased capacity)



1.Increased NPSHr value
2.Increased suc.pipe resistance

8-5. Required shaft power

Theoretical shaft power **"Lw"** is obtained by theoretical calculation of the power of pump work volume.

$$Lw = \frac{\rho \times g \times H \times Q}{60 \times 10^3} \quad kW$$

$$\boxed{Lw = 0.163 \times \gamma \times Q \times H} \quad kW$$

H : Total head m
Q : Discharge capacity m^3/min
g : Gravitational constant $9.8\ m/s^2$
ρ: Density of liquid kg/m^3
γ: Specific gravity of liquid

Note: Here, density (ρ) is changed to specific gravity (γ) for the calculation.

Required shaft power **"Ld"** is the power which is actually needed for the pump. **"Ld"** value is larger than Lw value by the extent of loss.

$$Ld = \frac{Lw}{\eta} \times 100 \quad kW$$

$$\boxed{Ld = \frac{0.163 \times \gamma \times Q \times H}{\eta} \times 100} \quad kW$$

η : Pump efficiency %

$$\eta = \frac{Lw}{Ld} \times 100$$

Pump performance influenced by liquid conditions

1. Performance change by specific gravity

(Other condition than specific gravity is same as clean water)

- Discharge capacity No change
- Total head No change
- Shaft power Shaft power at clear water x specific gravity

2. Performance change by liquid viscosity

Pump performance is influenced by the liquid viscosity. If viscous liquid is pumped, head and discharge capacity are decreased and shaft power is increased. The extent of decrease and increase can not be theoretically calculated because it depends on pump construction, inside shape and roughness, however, JIS B8306 mentions the method to obtain the change of total head, discharge capacity and efficiency of centrifugal pumps as the corrected coefficient against standard performance when pumping clear water (in case of Newtonian liquid). Refer to item "8-6 Correction of performance".

(Note)Newtonian liquid is the liquid of which the viscosity is not influenced by stirring or shear as long as the temperature does not change.

8-6. Correction of performance

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

$$\text{Coefficient of kinematic viscosity (cSt)} = \frac{\text{Absolute viscosity (cP)}}{\text{Specific gravity } (\gamma)}$$

1cP＝1mPa・s

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.

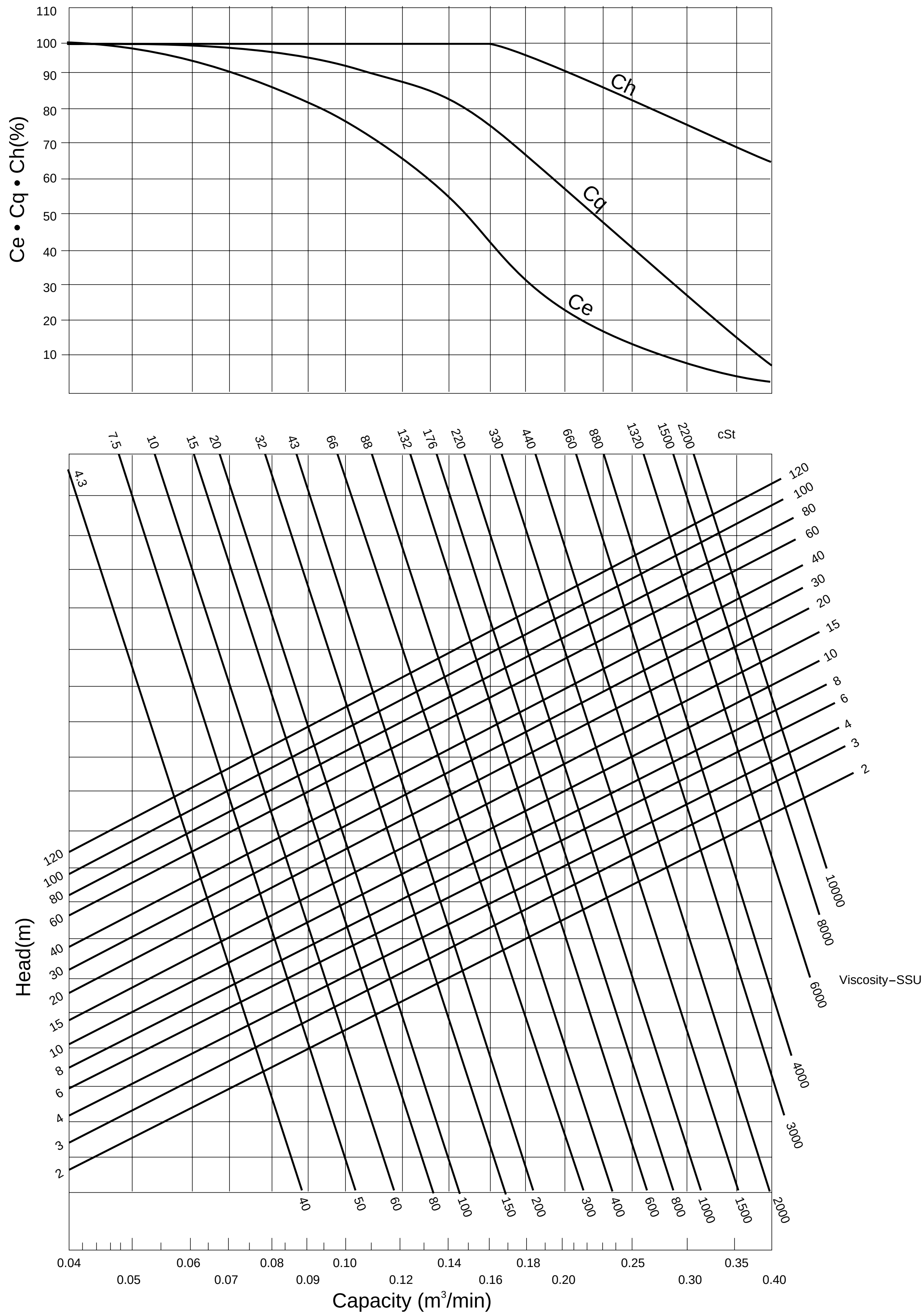
2-3. Vertically extend the line from the point 2 to get the respective intersection point with line Ch (head), Cq (capacity), Ce (efficient) to get the respective corrected coefficient (%).

3. Corrected head, corrected discharge capacity and corrected efficiency are obtained from following calculation, where Hw, Qw and Ew 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.

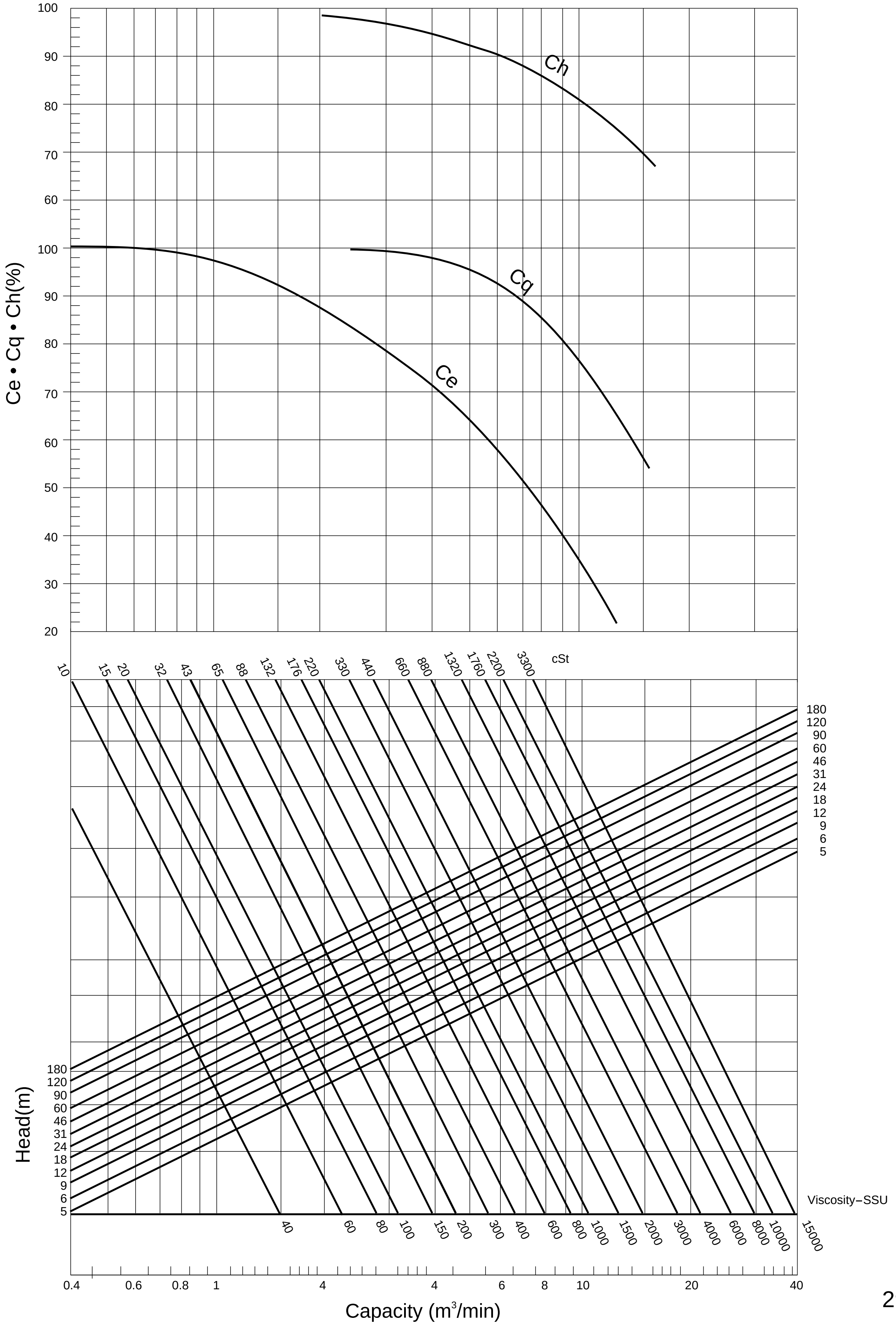
Corrected head	(m)	Hw x Ch
Corrected capacity	(m^3/min)	Qw x Cq
Corrected efficiency	(%)	Ew x Ce

$$\underset{\text{(kW)}}{\text{Corrected shaft power}} = \frac{0.163 \times \text{Specific gravity x Corrected head x Corrected capacity}}{\text{Corrected efficiency/100}}$$

Perfomance correction diagram for less than 0.4m³/min



Perfomance correction diagram for 0.4m³/min to 40m³/min



9. Piping

9-1. Precautions on installation and piping

1. Location

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

2. Installed position

- Install and fix the pump on the foundation which is not affected by vibration generated by other machines.
- Keep enough space around the pump for the back pull-out of motor, assembly and disassembly of the pump.
- Foundation area must be larger than pump baseplate.

3. Protect the pump from water hammer

- Do not employ the valve such as solenoid valve and automatic valve which opens or closes quickly.
- If quick motion valve is used, opening or closing motion should be done slowly.
- If discharge piping is longer than 15 or 20 meters, install the check valve and by-pass valve (or relief valve) near to the pump.

(Note) Water hammer is the phenomenon that the liquid pressure drastically changes as the flow in the pipe quickly changes because of any reason.Water hammer may happen due to quick opening or closing of valve, back flow of liquid to the check valve when the pump is stopped, or quick starting of pump etc. Pay much more attention to water hammer than metal made conventional pumps because MDM pumps are made of plastics.

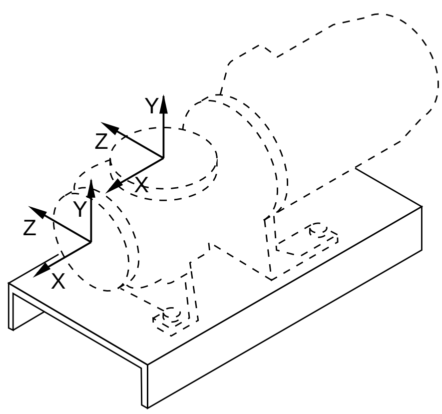
9-2. Pipe load and moment

Allowable pipe load put on pump flange

Direction of load	Load kN			
	Discharge flange		Suction flange	
	25,40,50	65	25,40,50	65
Fx	0.71	1.07	0.89	1.33
Fy(Pression/Tension)	0.89/0.44	1.33/0.67	0.58	0.89
Fz	0.58	0.89	0.71	1.07

Allowable moment put on pump flange

Direction of load	Moment kN • m			
	Discharge flange		Suction flange	
	25,40,50	65	25,40,50	65
Mx	0.35	0.72	0.46	0.95
My	0.46	0.95	0.35	0.72
Mz	0.23	0.47	0.23	0.47



9-3. Suction piping

1. Flooded suction	• Flooded suction is recommended.
2. Pipe diameter	• Pipe diameter should be larger than pump inlet bore.
3. Shortest piping	• Employ less bends and shortest piping length.
4. Straight piping	• Employ straight pipe just before pump inlet port. • Pump inlet bore of 50 mm or smaller : Straight pipe of 500 mm or longer • Pump inlet bore of 65 mm or larger : Straight pipe of 8 times as larger than inlet port
5. Air pocket	• Do not allow any projection where air may be trapped along the suction pipe Suction pipe should have an ascending gradient of 1/100 toward the pump.
6. 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.
7. Gate valve in suction side	• In case of flooded suction, install gate valve in suction piping. It is needed when the pump is disassembled and inspected.
8. Piping for flushing	• Install pump flushing piping in case that the dangerous liquid will be handled.
9. End of suction piping	• The end of suction pipe always should be located at 500 mm or more below the liquid level.
10. 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.
11. Pipe support	• Install the pipe support so that the weight of pipe can not be directly loaded to the pump.

9-4. Discharge piping

1. Pipe diameter
- In case that the discharge piping is long and at the same time the pipe diameter is the same as pump bore, the specified performance may not be obtained because of unexpected pipe resistance. Calculate the pipe resistance to decide proper diameter of pipe.

2. Gate valve
- Install the gate valve in discharge piping to adjust flow rate and to protect motor from over loading. If the check valve is also installed, recommended arrangement is : Pump→Check valve→Gate valve

3. Pressure gauge
- Install the pressure gauge in discharge piping to check the operating conditions such as discharge head etc.

4. Check valve
- Check valve must be installed in the following cases.
  1. Discharge piping is longer than 15 to 20 meters.
  2. Actual head exceeds 15 meters.
  3. Height difference between liquid level and discharge pipe end exceeds 9 meters.
  4. When two pumps are used in parallel.

5. Air vent
- If horizontal discharge piping is longer than 15 to 20 meters, install air vent on the way.

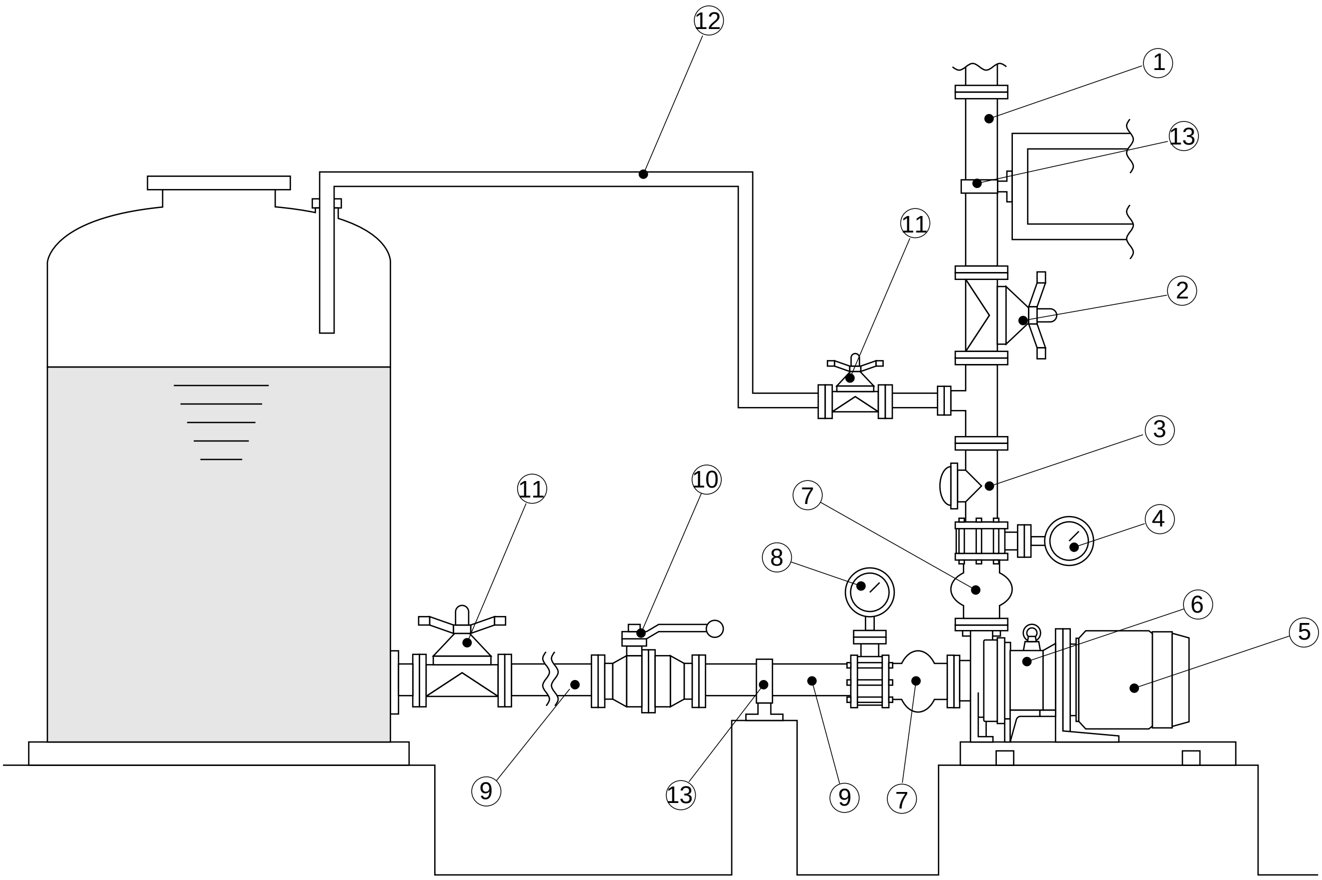
6. Drain
- If the liquid must be drained to protect pump from freezing, install the drain valve.

7. Pipe support
- Install the pipe support so that the pipe weight can not be loaded to pump.

8. Priming piping
- Install piping for priming in case of suction lift.

9. By-pass piping
- If the pump is used with discharge valve closed for small discharge capacity, install the by-pass piping so that the liquid can come back to the pump chamber.

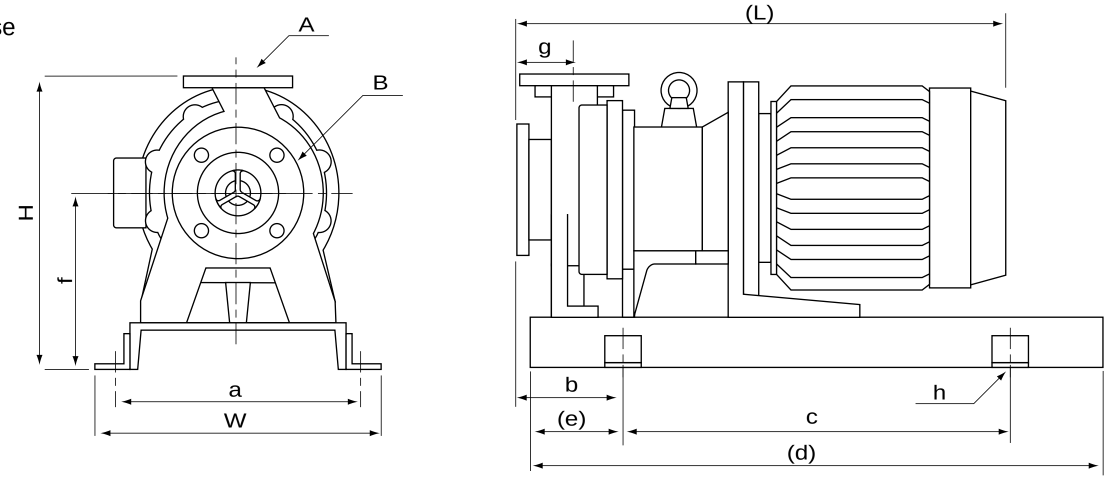
9-5. Example of recommended piping



① Discharge pipe
② Gate valve
③ Check valve
④ Pressure gauge
⑤ Motor
⑥ Pump
⑦ Flexible joint
⑧ Vacuum gauge
⑨ Suction pipe
⑩ Suction valve
⑪ Gate valve
⑫ Air vent piping
⑬ Pipe support

10. Dimensions

With base

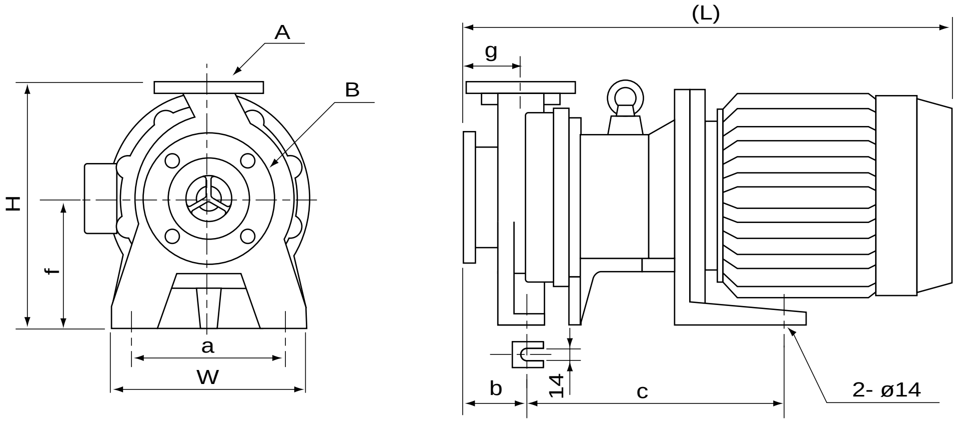


in mm

Model	Motor	W	H	(L)	a	b	c	(d)	(e)	f	g	h	A	B	Mass
MDM25-1	1.5kW	400	400	494	350	135	480	710	115	240	80	4- ø19	25A	40A	85kg
	2.2kW														
MDM25-2	3.7kW	400	430	611	350	150	540	800	130	250	80	4- ø19	25A	40A	120kg
	5.5kW			667											140kg
	7.5kW														145kg
MDM40	3.7kW	400	410	611	350	150	540	800	130	250	80	4- ø19	40A	50A	115kg
	5.5kW			667											135kg
	7.5kW														140kg
MDM50	3.7kW	400	410	611	350	150	540	800	130	250	80	4- ø19	50A	65A	120kg
	5.5kW			667											135kg
	7.5kW														140kg
MDM65	5.5kW	400	430	687	350	170	540	800	130	250	100	4- ø19	65A	80A	140kg
	7.5kW														145kg
	11kW	480	500	854	430	190	600	900	150	320					215kg
	15kW														220kg

(Note) Mass includes Hitachi motor.

Without base

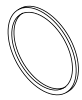


in mm

Model	Motor	W	H	(L)	a	b	c	f	g	A	B	Mass
MDM25-1	1.5kW	180	310	494	130	100	150	150	80	25A	40A	60kg
	2.2kW											
MDM25-2	3.7kW	280	360	611	220	90	285	180	80	25A	40A	95kg
	5.5kW			667			365					110kg
	7.5kW											115kg
MDM40	3.7kW	280	340	611	220	90	285	180	80	40A	50A	90kg
	5.5kW			667			365					105kg
	7.5kW											110kg
MDM50	3.7kW	280	340	611	220	90	285	180	80	50A	65A	90kg
	5.5kW			667			365					105kg
	7.5kW											110kg
MDM65	5.5kW	280	360	687	220	110	365	180	100	65A	80A	115kg
	7.5kW											120kg
	11kW	280	410	854	220	110	450	230				170kg
	15kW											175kg

(Note) Mass includes Hitachi motor.

11.Spare parts list

NO.	Parts name	Material	Sketch	Q'ty/unit	Remarks
310	Bearing	ECF : High density carbon EKK PKK : SIC		1	
314.2	Mouth ring	ECF : Filler charged PTFE EKK PKK : SiC		1	
400.1	Gasket	PTFE		1	PTFE covered
314.3	Rear thrust	ECF EKK : Filler charged PTFE PKK : PTFE		1	
314.4	Rear ring	ECF : High purity alumina ceramic EKK PKK : SiC		1	
400.2	Drain gasket	PTFE		1	With drain type
400.3	Air vent gasket	PTFE		1	With drain type of PFA material

12.Chemical resistance chart

X : Not usable BP : Boiling Point

No.	Liquid	Molecular formula	Specific gravity	Concentration %	Temperature Max.˚C		
					PFA	ETFE	
					KK	KK	CF
1	Acetic acid	CH_3COOH	1.05	50	100	80	80
2	Acetone	CH_3COCH_3	0.79	100	BP	BP	BP
3	Acetyl chloride	CH_3COCl	1.1	100	80	X	X
4	Adipic acid	$COOH(CH_2)_4COOH$	1.19	60	120	100	100
5	Aluminum chloride	$AlCl_3$	1.42	50	120	100	100
6	Aluminum nitrate	$Al(NO_3)_3$	1.4	40	100	100	100
7	Aluminum sulphate	$Al_2(SO_4)_3$	1.21	27.6	100	100	100
8	Ammonia water	NH_4OH	0.89	30	120	100	100
9	Ammonium chloride0	NH_4Cl	1.07	27	120	100	100
10	Ammonium fluoride	NH_4F	1	50	120	100	100
11	Ammonium nitrate	NH_4NO_3	1.17	40	120	100	100
12	Ammonium oxalate	$(NH_4)_2C_2O_4.H_20$	1.04	10.5	120	100	100
13	Ammonium perchlorate	NH_4ClO_4	1.11	20	120	100	40
14	Ammonium persulfate	$(NH_4)_2S_2O_6$	1.22	37	120	100	100
15	Ammonium phosphate	$(NH_4)_3PO_4$		17	120	100	100
16	Aniline	$C_6H_5NH_2$	1.02	100	120	40	40
17	Aqua regina	$HCl+HNO_3$ (3:1)			60	20	X
18	Arsenic acid	H_3AsO_4	1.02	14	120	100	100
19	Barium carbonate	$BaCO_3$	1	Saturated	120	100	100
20	Barium chloride0	$BaCl_2$	1.15	15	120	100	100
21	Barium nitrate	$Ba(NO_3)_2$	1.06	8.5	120	100	100
22	Benzaldehyde	C_6H_5CHO	1.05	100	40	20	20
23	Benzoyl chloride	C_6H_5COCl	1.22	100	60	X	X
24	Boric acid	H_3BO_3	1.07	23	120	100	100
25	Bromine water	Br_2+H_2O		Saturated	80	X	X
26	Butyl alcohol	C_4H_3OH	0.81	100	BP	BP	BP
27	Butyl alcohol	C_4H_3OH	0.81	100	BP	BP	BP
28	Calcium chlorate	$Ca(ClO_3)_2$		60	120	100	40
29	Calcium chloride	$CaCl_2$	1.39	40	120	100	100
30	Calcium hydroxide	$Ca(OH)_2$	1	0.13	120	100	100
31	Calcium nitrate	$Ca(NO_3)_2$	1.17	25	120	100	100
32	Calcium sulphate	$CaSO_4$	1	0.19	120	100	100
33	Carbonic acid	H_2CO_3		Saturated	120	100	100
34	Caustic potash	KOH		→ Same as caustic soda			
35	Caustic soda	NaOH	1.11	10	120	100	100
36	Caustic soda	NaOH	1.22	20	120	100	100
37	Caustic soda	NaOH	1.53	50	120	100	100
38	Chlorine dioxide	ClO_2	1.04	6	40	20	20
39	Chlorine water	Cl_2+H_2O		0.7	120	100	40
40	Chloroacetic acid	$CH_2ClCOOH$	1.19	50	120	100	100
41	Chloroform	$CHCl_3$	1.5	100	60	X	X
42	Chromic acid	H_2CrO_4	1.94	60	80	80	X
43	Citric acid		1.33	50	120	100	100
44	Copper carbonate	$CuCO_3$	1.1	Saturated	120	100	100
	Copper cyanide	$Cu(CN)_2$	1	Saturated	120	100	100
	Copper fluoride	CuF	1	0.75	80	70	50
45	Copper nitrate	$Cu(NO_3)_2$	1.34	50	120	100	100
46	Copper sulphate	$CuSO_4$	1.04	5	100	100	100
47	Cresol	$C_6H_4OHCH_3$	1.05	100	80	40	40
48	Cyanic acid	HCN	0.96	20	120	100	100
49	Cyclohexane	C_8H_{12}	0.78	100	120	40	40

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No.	Liquid	Molecular formula	Specific gravity	Concentration %	Temperature Max.˚C		
					PFA	ETFE	
					KK	KK	CF
50	Cyclohexanol	$C_6H_{11}OH$	0.97	100	80	40	40
51	Dichloroethane	$C_2H_4Cl_2$	1.25	100	80	X	X
52	Dichloroethylene	$C_2H_2Cl_2$	1.21	100	80	X	X
53	Dimethylamine	$(CH_3)_2NH$	0.69	100	BP	BP	BP
54	Efhylenediamine tetraacetic acid			100	40	20	20
55	Ethyl alcohol	C_2H_5OH	0.79	100	BP	BP	BP
56	Ethylene glycol	$CH_2OH.CH_2OH$	1.11	100	120	100	100
57	Fatty acid	$CH_3(CH_3)_2COOH$		100	120	40	40
58	Ferric chloride	$FeCl_3$	1.5	47.9	120	100	100
59	Ferric nitrate	$Fe(NO_3)_3$	1.07	16	120	100	100
60	Ferric sulphate	$FeSO_4$	1.25	30	120	100	100
61	Ferrous chloride	$FeCl_2$	1.4	38.5	120	100	100
62	Ferrous nitrate	$Fe(NO_3)_2$	1.22	45	120	100	100
63	Ferrous sulphate	$Fe_2(SO_4)_3$	1.17	21	120	100	100
64	Formic acid	HCOOH	1.22	100	80	40	40
65	Gasoline			100	100	100	100
66	Glycerin	$(CH_2OH)_2CHOH$	1.46	100	120	100	100
67	Heptane	C_6H_{16}	0.68	100	120	100	100
68	Hydrazine	N_2H_4	1.01	100	50	50	50
69	Hydrobromic acid	$HBrO_3(HBr)$	1.46	50	120	X	X
70	Hydrochloric acid	HCl	1.18	38	120	100	100
71	Hydrofluoric acid	HF	1.15	50	80	70	20
72	Hydrogen peroxide	H_2O_2	1.44	100	120	100	X
73	Hydroiodic acid	HI	1.4	40	100	80	80
74	Hydrosillicofluoric acid	H_2SiF_6	1.13	50	80	70	X
75	Hypochlorous acid	HClO		10	120	100	X
76	Kerosene			100	120	100	100
77	Lactic acid	$C_3H_6CH_3$	1.03	16	120	100	100
78	Lead acetate	$Pb(CH_3COO)_2.3H_2O$	1.4	40	120	100	100
79	Magnesium carbonate	$MgCO_3$	1.21	0.15	120	100	100
80	Magnesium chloride	$MgCl_2$	1.3	34	120	100	100
81	Magnesium fluoride	MgF_2	1.03	4	80	70	50
82	Magnesium hydroxide	$Mg(OH)_2$	1	Saturated	120	100	100
83	Magnesium nitrate	$Mg(NO_3)_2$	1.1	24	120	100	100
84	Magnesium sulphate	$MgSO_4$	1.19	25.3	120	100	100
85	Maleic acid	HCOOH=CHCOOH	1.42	80	120	100	100
86	Manganese chloride	$MnCl_2$	1.18	20	120	100	100
87	Mercuric nitrate	$Hg(NO_3)_2$	1.16	25	100	20	20
88	Mercurous chloride	Hg_2Cl_2		Saturated	120	100	100
89	Mercurous chloride	$HgCl_2$	1.05	6	120	100	100
90	Mercurous nitrate	$Hg_2(NO_3)_2$	1.22	23	100	20	20
91	Methanol	CH_3OH	0.79	100	BP	BP	BP
92	Mixture acid	H_2SO_4+NHO_3	1.68		80	50	X
93	Mixture acid	H_2SO_4+H_2CrO_4	2.2		60	20	X
94	Naphtha			100	120	100	100
95	Nickel chloride	$NiCl_2$	1.1	10	120	100	100
96	Nickel nitrate	$Ni(NO_3)_2$	1.33	48	120	100	100
97	Nickel sulphate	$NiSO_4$	1.26	28	120	100	100
98	Nitric acid	HNO_3	1.35	50	100	80	X
99	Nitrous acid	HNO_2		40	120	100	100
100	Oleic acid	$C_{18}H_{34}O_2$	0.89	100	120	100	100

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No.	Liquid	Molecular formula	Specific gravity	Concentration %	Temperature Max.˚C		
					PFA	ETFE	
					KK	KK	CF
101	Oleum	H_2SO_4+SO_3	1.92		40	20	X
102	Oxalic acid	$(COOH)_2.2H_2O$	1.9	100	120	100	100
103	Perchloric acid	$HClO_4$	1.46	40	120	100	40
104	Perchloroethylene	C_2Cl_4	1.62	100	80	X	X
105	Phenol	C_6H_5OH	1.07	100	120	100	100
106	Phenol	C_6H_5OH	1.07	100	120	100	100
107	Phosphoric acid	H_3PO_4	1.25	40	120	100	100
108	Phosphoric acid	H_3PO_4	1.69	85	50	50	20
109	Photographic developer				120	100	100
110	Photographic fixative				100	80	80
111	Picric acid	$C_6H_3O_7N_3$	1.03	6.2	120	100	100
112	Potassium bicarbonate	$KHCO_3$	1.03	5	120	100	100
113	Potassium bromide	KBr	1.37	40	120	100	100
114	Potassium carbonate	K_2CO_3	1.45	53	120	100	100
115	Potassium chlorate	$KClO_3$	1.04	6.8	120	100	40
116	Potassium chloride	KCl	1.28	36	120	100	100
117	Potassium chromate	K_2CrO_4	1.39	40	120	100	X
118	Potassium cyanide	KCN	1.16	40	120	100	100
119	Potassium dichromate	$K_2Cr_2O_7$	1.07	10	120	100	X
120	Potassium ferricyanide	K_3 $(Fe(CN)_6)$	1.16	30	120	100	100
121	Potassium ferrocyanide	K_4 $(Fe(CN)_6)$	1.1	20	120	100	100
122	Potassium fluoride	KF	1.42	50	80	70	50
123	Potassium hydroxideh	KOH		Refer to caustic potash			
124	Potassium iodide	KI	1.89	60	120	100	100
125	Potassium nitrate	KNO_3	1.16	24	120	100	100
126	Potassium perchlorate	$KClO_4$	1.01	1.8	120	100	40
127	Potassium permanganate	$KMnO_4$	1.03	4	X	X	40
128	Sea water				120	100	100
129	Silver cyanide	AgCN		Saturated	120	100	100
130	Silver nitrate	$AgNO_3$	1.69	50	120	100	100
130	Sodium bisulfate	$NaHSO_3$		Saturated	120	100	100
132	Sodium bisulfate	$NaHSO_4$	1.04	5	120	100	100
133	Sodium carbonate	Na_2CO_3	1.1	100	120	100	100
134	Sodium chlorate	$NaClO_3$	1.23	30	120	100	40
135	Sodium chloride	NaCl	1.19	25	120	100	100
136	Sodium chlorite	$NaClO_2$		10	120	100	X
137	Sodium cyanide	NaCN	1.22	40	120	100	100
138	Sodium dichromate	Na_2CrO_7	1.4	60	120	100	X
139	Sodium ferricyanide	Na_4 $(Fe(CN)_6)$	1.1	30	120	100	100
140	Sodium ferrocyanide	Na $(Fe(CN)_6)$	1.17	50	120	100	100
141	Sodium fluoride	NaF	1.03	4	120	100	100
142	Sodium hydroxide	NaOH		Refer to caustic soda			
143	Sodium hypochlorite	NaClO	1.14	12	100	100	X
144	Sodium iodide	NaI	1.61	64	120	100	100
145	Sodium nitrite	$NaNO_2$	1.3	45	120	100	100
146	Sodium oxalate	$Na_2(COO)_2$	1.11	17.5	120	100	100
147	Sodium peroxide	Na_2O_2	1.35	40	120	100	X
148	Sodium perborate	$NaBO_3$	1.04	5	120	100	100
149	Sodium phosphate	Na_3PO_4	1.02	4	120	100	100
150	Sodium sulphate	Na_2SO_4	1.1	14	120	100	100
	Sodium thiosulfate	$Na_2S_2O_3$		41	120	80	80

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No.	Liquid	Molecular formula	Specific gravity	Concentration %	Temperature Max.˚C		
					PFA	ETFE	
					KK	KK	CF
151	Stannic chloride	$SnCl_4$	2.2	100	120	100	100
152	Stannous chloride	$SnCl_2$	1.77	60	120	100	100
153	Sulfuric acid	H_2SO_4	1.62	70	120	100	80
154	Sulfuric acid	H_2SO_4	1.84	98	100	100	50
155	Sulfurous acid	H_2SO_3	1.06	10	120	100	100
156	Tartaric acid	$C_4H_6O_6$	1.2	40	120	100	100
157	Tetrachloro carbon	CCl_4	1.59	100	80	X	X
158	Toluene	$C_6H_5CH_3$	0.87	100	40	20	20
159	Trichloroethylene	$C_2H_2Cl_3$	1.33	100	80	X	X
160	Vinegar				120	100	100
161	Zinc chloride	$ZnCl_2$	1.57	100	120	100	100
	Zinc cyanide	$Zn(CN)_2$	1.05	10	120	100	100
162	Zinc nitrate	$Zn(NO_3)_2$	1.75	60	120	100	100
163	Zinc sulphate	$ZnSO_4$	1.33	53	120	100	100
164	Plating solution						
164-1	Brass				120	100	100
164-2	Cadmium				120	100	100
164-3	Chromium sulfate				120	100	100
164-4	Chromium sulfate				120	100	X
164-5	Copper acid bath				120	100	100
164-6	Copper alkali bath				100	80	80
164-7	Gold				120	100	100
164-8	Lead				120	100	100
164-9	Nickel (non-lucid)				120	100	100
164-10	Nickel (lucid)				120	100	100
164-11	Pewter (non-lucid)				120	100	100
164-12	Pewter(lucid)				120	100	100
164-13	Rhodium				120	100	100
164-14	Silver				120	100	100
164-15	Silver alkali bath				120	100	100
164-16	Tin acid bath				120	100	100
164-17	Tin alkali bath				120	100	100
164-18	White gold				120	100	100
164-19	Zinc acid bath				120	100	100
164-20	Zinc alkali bath				120	100	100

(Note) 1. X : Not usable. BP : Boiling point.

2. This table is made based on the data given by material manufacturers and the experience so far but is not the guarantee for the chemical resistibility or wear by liquid.