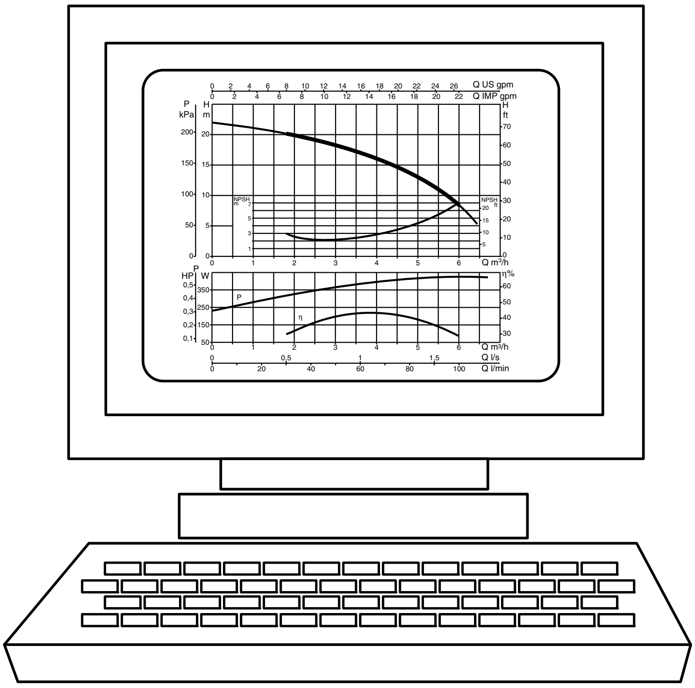
TECHNICAL APPENDIX



CONVERSION TABLE FOR UNITS OF MEASUREMENT

Characteristic	System	Units	Symbol	CONVERSION FACTORS		
				System	International System (SI)	Imperial System
LENGHT	Technical and International	metre decimetre centimetre millimetre	m dm cm mm	1 dm = 0,1 m 1 cm = 0,01 m 1 mm = 0,001 m		1 m = 3,28 ft 1 dm = 3,937 in 1 cm = 0,3937 in
	Imperial	inch foot yard	in ft yd	1" = 25,4 mm 1 ft = 0,3048 m 1 yd = 0,9144 m		1 ft = 12" 1 yd = 3 ft = 36"
AREA	Technical and International	metres squared centimetres squared millimetres squared	m^2 cm^2 mm^2	1cm^2 = 0,0001 cm^2 1 mm^2 = 0,01 cm^2		1m^2 = 1.196 sq.yd 1m^2 = 10.764 sq.ft 1 cm^2 = 0.155 sq.in
	Imperial	squared inch squared foot squared yard	sq.in sq.ft sq.yd	1 sq.in = 6,45 cm^2 1 sq.ft = 0,0929 m^2 1 sq.yd = 0,836 m^2		1 sq.ft = 144 sq.in 1 sq.yd = 1.296 sq.in 1 sq.yd = 9 sq.ft
VOLUME	Technical and International	metre cubed decimetre cubed centimetre cubed litre cubed	m^3 cm^3 mm^3 l	1 m^3 = 1.000 dm^3 1 cm^3 = 0.001 m = 1.000 cm^3 1 mm^3 = 0.001 dm^3 1 l = dm^3		1 dm^3 = 0.22 Imp.gal 1 dm^3 = 0.264 US.gal 1 dm^3 = 61.0 cu.in
	Imperial	cubic inch cubic feet imperial gallons U.S. gallons	cu.in cu.ft Imp.gal USA.gal	1 cu.in = 16,39 cm^3 1 cu.ft = 28,34 dm^3 1 Imp.gal = 4,546 dm^3 1 US.gal = 3,785 dm^3		1 Imp.gal = 1,201 US.gal 1 US.gal = 0,833 Imp.gal
TEMPERATURE	Technical and International	degrees Centigrade degrees Kelvin	°C °K	°C = °K-273 °K = °C + 273		°C = 5/9 x (°F - 32) °K = 5/9 x (°F - 32) + 273
	Imperial	degrees Fahreinheit	°F	°F = 9/5 x °C + 32		–
	Freezing point of water at atmospheric pressure: Boiling point of water at atmospheric pressure:			0°C = 273 °K = 32 °F 100°C = 373 °K = 212 °F		
WEIGHT AND FORCE	Technical	kilogram	kg	–	1 kg = 9,81 N	1 kg = 2,203 lb
	International	Newton	N	1 N = 0,102 kg	–	1 N = 0,22546 lb
	Imperial	pound	lb	1 IB = 0,454 kg	1 lb = 4,452 N	–
SPECIFIC WEIGHT	Technical	kilogram per decimetre cubed	kg/dm^3	–	1 kg/dm^3 = 9,807 N/dm^3	1 kg/dm^3 = 62,46 lb/cu.ft
	International	Newton per decimetre cubed	N/dm^3	1 N/dm^3 = 0,102 kg/dm^3	–	1 N/dm^3 = 6,369 lb/cu.ft
	Imperial	pound per cubic foot	lb/cu.ft	1 lb/cu.ft = 0,01600 kg/dm^3	1 lb/cu.ft = 0,160 N/dm^3	–
PRESSURE	Technical	atmospheres	kg/cm^2	–	1 kg/cm^2 = 98,067 kPa 1 kg/cm^2 = 0,9807 bar	1 kg/cm^2 = 14,22 psi
	International	Pascal kiloPascal bar	Pa kPa bar	1 kPa = 0,0102 kg/cm^2 1 bar = 1,02 kg/cm^2	1 kPa = 1.000 Pa 1 bar = 100.000 Pa	1 kPa = 0,145 psi 1 bar = 14,50 psi
	Imperial	pounds per square inch	psi	1 psi = 0,0703 kg/cm^2	1 psi = 0,06895 bar 1 psi = 6,894 kPa	–
FLOW	Technical	litres per minute litres per second metres cubed per second	l/min l/s m^3/h	1 l/min = 0,0167 l/s 1 l/s = 3,6 m^3/h 1 m^3/h = 16,667 l/min	1 l/s = 0,001 m^3/s	1 l/min = 0,22 imp.g.p.m. 1 l/min = 0,264 US.g.p.m. 1 m^3/h = 3,666 imp.g.p.m. 1 m^3/h = 4,403 US.g.p.m.
	International	metres cubed per second	m^3/s	1 m^3/s = 1.000 l/s 1 m^3/s = 3.600 m^3/h	–	1 m^3/s = 13.198 imp.g.p.m. 1 m^3/s = 15.852 US.g.p.m.
	Imperial	Imperial gallons per minute U.S. gallons per minute	Imp.g.p.m. US.g.p.m.	1 Imp.g.p.m. = 4,546 l/min 1 Imp.g.p.m. = 0,273 m^3/h 1 US.g.p.m. = 3,785 l/min 1 US.g.p.m. = 0,227 m^3/h	–	1 Imp.g.p.m. = 1,201 US.g.p.m. 1 US.g.p.m. = 0,833 Imp.g.p.m.
TORQUE	Technical	kilogram metre	kgm	–	1 kgm = 9,807 Nm	1 kgm = 7,233 ft.lb
	International	Newton metre	Nm	1 Nm = 0,102 kgm	–	1 Nm = 0,7376 ft.lb
	Imperial	foot pound	ft.lb	1 ft.lb = 0,138 kgm	1 ft.lb = 1,358 Nm	–
WORK AND ENERGY	Technical	kilogrammo metres horsepower hours	kgm CVh		1 kgm = 9,807 J 1 CVh = 0,736 kWh	1 kgm = 7,233 ft.lb 1 Nm = 0,986 HP.hr.
	International	Joule kiloWatt hour	J kWh	1 J = 0,102 kgm kWh = 1,36 CVh	–	1 Nm = 0,7376 ft.lb 1 Nm = 0,7376 ft.lb
	Imperial	foot pound Horsepower hour	ft.lb HP.hr.	1 ft.lb = 0,138 kgm 1 HP.hr. = 1,014 CVh	1 ft.lb = 1.358 Nm 1 HP.hr. = 0,746 kWh	–
POWER	Technical	Horse power	HP	1 HP = 0,736 kW	1 HP = 736 W	–
	International	Watt kiloWatt	W kW	1 W = 0,00136 HP 1 kW = 1,36 HP	1 kW = 1.000 W	–
KINETIC VISCOSITY	Technical	stokes centistokes	St cSt	1 St = 1 cm^2/s 1 cSt = 0,01 St	1 St = 0,0001 m^2/s	1 St = 0,00107 ft^2/s
	International	metre squared per second	m^2/s	1 m^2/s = 10.000 St	1 m^2/s = 10.000 cm^2/s	1 m^2/s = 10,764 ft^2/s
	Imperial	square feet per second	ft^2/s	1 ft^2/s = 929 St	1 ft^2/s = 0,0929 m^2/s	–

GENERAL INFOMATION

Terms used in pumping

The following is a list of terms used in pumping with an explanation of what they mean. All measurements are given in Technical units and reference should be made to the chart on page 2 for their equivalents.

Head

Head means height, difference in level, gradient. When it is said that a pump has a flow of Q litres per second and a head of 30 metres it means that the pump is capable of raising Q litres of liquid through 30 metres every second.
For any given pump, the head is determined by the details of its construction such as the external diameter of the impeller and the speed of rotation and is independent of the liquid being pumped. This means that the pump can raise through 30 metres, Q litres per second of water, petrol mercury, etc and only the power of the motor will have to be different for the three examples given.

Specific weight

The specific weight of a liquid or fluid is the weight per unit volume of the liquid. Specific weight is usually measured in kg/dm^3 remembering that 1 dm^3 = 1 litre.

Pressure

Pressure means weight per unit area (e.g. kg/cm^2) and is a term which should not be confused with head. In the case of liquids, the pressure that the liquid exerts on a surface is given by the product of the height of the liquid and its specific weight. For this reason the column of several km of air on the earth's surface produces at sea level a pressure of about $1kg/cm^2$ (equal to approx. 1 atmosphere). If the same column were of water rather than air, the pressure would be some 700 to 800 times greater, due to the fact that water has a specific weight some 700-800 times greater than that of air.
Bearing in mind that a column of water 10m high is equivalent to approx. 1 kg/cm^2, if we placed a manometer on the outlet of our example pump (30m head) the following pressure increases would be measured.

a) with petrol (specific weight 0.7 kg/dm^3) = 0.7 x 0.001 x 30 x 100 = 2.1 kg/cm^2
b) with water (specific weight 1.0 kg/cm^3) = 1 x 0.001 x 30 x 100 = 3.0 kg/cm^2
c) with mercury (specific weight 13.6 kg/cm^3) = 13.6 x 0.001 x 30 x 100 = 40.8 kg/cm^2

Flow

Flow means the quantity of liquid to pass across a surface, such as the delivery aperture of a pump or a cross section of a pipe, in a unit of time.
This can be measured in litres per minute (l/min), litres per second (l/s), cubic metres per hour (m^3/h) etc.
It should be noted that there is a close analogy between the flow of water in a pipe and the flow of electricity in a wire. Hydraulic head is equivalent to electrical potential or voltage and hydraulic flow is equivalent to electrical current.
Even the behaviour of these properties is the same. Just as a thin wire restricts the flow of electricity more than a thick one, so a small bore pipe offers a greater resistance to the flow of a liquid than a large one.
In hydraulics this resistance is called head loss and is dependent on the quality of the pipe (e.g. material, shape, roughness etc.) and on its cross sectional area. The velocity of the liquid is also a factor.

Head loss

Head loss is that part of the head, possessed by the liquid, which is lost in passing through a pipe or a valve or a filter etc. This loss is not recoverable as it is lost due to friction. Returning to the electrical analogy, just as the losses in a cable are proportionately higher as the current increases, so the head loss is proportionately greater as the speed of the liquid increases. So the more the flow is restricted by scaled pipes, clogged filters, partially closed valves etc. the greater the head loss will be.

Pumps

A machine which is used to give a certain head to a liquid which passes through it. The head can be used to raise the liquid to a higher level or to flow within a pipe.
The characteristics of a pump are:

a) **Flow** (that is the quantity of liquid that is moved through the pump in a unit of time)

b) **Head** (that is the height through which the pump is capable of heading the liquid)

According to the relationship existing between the flow and head it is possible to have:

a) Pumps of small flow and large head (piston pumps, rotary pumps, small centrifugal pumps)

b) Pumps of medium fl`ow and head (centrifugal pumps in general)

c) Pumps of large flow and small head (heliocentrifugal pumps and propeller pumps)

The centrifugal pumps, heliocentrifugal pumps and propeller pumps have a rotary motion and their speed is measured in revolutions per minute (rpm). For these pumps operating at a given speed for any given value of flow, there is only one value of head. This means that if it is wished to vary the performance of a pump of this type, it is necessary to vary the speed accordingly. In effect the liquid which is passing through the pump is supplied with energy related to the head and velocity of the liquid itself.
This supplied energy is known as delivered power.

Delivered power

Delivered power is the power delivered by the pump to the liquid. The value of this delivered power depends upon three factors: flow, head and specific weight of the liquid. For example a pump which delivers petrol does less work than when it delivers sulphuric acid, because the specific weights of the two liquids are different. To pump a liquid a pump must be drivenby a motor which in the majority of cases is either electric or internal combustion. The power which the pump needs to operate is the absorbed power.

Absorbed power

Absorbed power is the power that the pump absorbs from the motor to give the liquid the delivered power.
Not all the absorbed power becomes delivered power as some power is lost through friction and another more important part is lost within the pump itself through hydraulic losses. It is therefore clear that the delivered power is always less than the absorbed power and the relation between the two is a number which is always less than one and is expressed as a percentage. This number is known as the efficiency.

Efficiency

The efficiency is obtained by dividing the delivered power by the absorbed power. For example a pump that is 75% efficient only delivers 75% of the absorbed power, the remaining 25% being lost as heat, friction etc. It is evident that the higher the efficiency of a pump the smaller the proportion of the absorbed power that is lost. If then the cost of energy is taken into account it is immediately apparent just how important efficiency is.
If we compare two pumps with 1 HP delivered power, one being 50% efficient and the other 60%, it can be seen that the first will need an absorbed power of only 2 HP to supply 1 instead of the second only 1,67 HP. This means that the efficiency of a pump expresses better than any other parameter the quality of the pump and the relative saving in terms of operating costs.

The head of a pump and its measurement

The head of a pump means the head given by the pump and it is generally expressed in metres. To ascertain the head of a surface pump it is necessary to measure, while it is operating, the value of the head at the suction and delivery connections, taking care that both readings are taken in relation to one common level known as the plane of reference. According to the installation it is possible to have two cases:

1) The value of the head at the suction connection is negative (i.e. below zero on the manometer) which is the case whent he level of the liquid being raised is lower than the level of the suction connection.

2) The value of the head at the suction connection is positive (i.e. above zero on the manometer) which is the case when the level of the liquid being raised is above the level of the suction connection (flooded suction).

In the first case the head of the pump is given by the sum of the two readings while in the second it is given by subtracting the value of the head at the suction connection from the value at the delivery connection.
It is necessary finally to check that the readings at the suction and delivery connections have been taken from apertures of the same diameter so that the readings are not distorted by a difference in velocity of the liquid. The correction is made by calculating the dynamic head, that is the part of the head possessed by the liquid due to its movement. The dynamic head Hd, expressed in metres, is calculated by the following formula.

$$Hd = \frac{v^2}{2g}$$

where: v = speed of the fluid at the measuring point, given in m/s
g = acceleration of gravity (9,81) given in m/s^2
2g = 2 x 9,81 = 19,62 m/s^2

The correction of the head is given by the difference between the dynamic head at the two connctions. It is therefore clear that if the two readings for a pump have been taken on pipes of the same diameter, that is the liquid is at the same velocity, the correction is zero.

For submersible pumps it is sufficient to measure the head at the delivery connection. The head is then given by adding the head, the dynamic head (at the delivery connection) and the difference in level between the free surface of the liquid and the manometer.

Developed power

Usually the developed power is given in kW or HP:

Q the flow
H the head in metres of the column of liquid (m.c.l.)
γ the specific weight of the liquid

The developed power (P3) is calculated by one of the following equations:

$$P3 = \frac{\gamma\,(kg/dm^3) \times Q\,(l/s) \times H\,(m.c.l.)}{75} \text{ in HP}$$

$$P3 = \frac{\gamma\,(kg/dm^3) \times Q\,(m^3/h) \times H\,(m.c.l.)}{270} \text{ in HP}$$

$$P3 = \frac{\gamma\,(kg/dm^3) \times Q\,(l/s) \times H\,(m.c.l.)}{102} \text{ in kW}$$

$$P3 = \frac{\gamma\,(kg/dm^3) \times Q\,(l/min) \times H\,(m.c.l.)}{4500} \text{ in HP}$$

$$P3 = \frac{\gamma\,(kg/dm^3) \times Q\,(m^3/h) \times H\,(m.c.l.)}{367} \text{ in kW}$$

$$P3 = \frac{\gamma\,(kg/dm^3) \times Q\,(l/min) \times H\,(m.c.l.)}{6120} \text{ in kW}$$

Calculating the power outputs

P_1 : the power absorbed by the motor in kW (generally shown by a wattmeter)
P_2 : the developed by the motor in kW
P_3 : the developed by the pump in kW

Power output of the motor $\eta = \frac{P_2}{P_1}$

Power output of the pump $\eta = \frac{P_3}{P_2}$

Combined power output $\eta = \frac{P_3}{P_1}$

Variation in head of a pump as the speed varies

The performance of a pump m is directly related to the speed of the pump in rpm (**n**). Providing there is no cavitation, the law of similarity may be used, which is expressed as follows.

$$Q_x = Q \times \frac{n_x}{n} \qquad H_x = H \times \left(\frac{n_x}{n}\right)^2 \qquad P_{2\text{-}x} = P_2 \times \left(\frac{n_x}{n}\right)^3$$

For example, doubling the number of revolutions (**n**$_x$) one has:
Q_x = the value of double flow
H_x = the value of four times the head
$P_{2\text{-}x}$ = the value of eight times the absorbed power

Q - H - P2 are the value at speed **n**
Q_x - H_x - $P_{2\text{-}x}$ are the value at speed **n**$_x$.

PRATICAL NOTES ON N.P.S.H.

N.P.S.H. are the initials of the expression Net Positive Suction Head.
The meaning of this expression is the absolute pressure which must exist in the suction port of the pump, to pump the liquid without causing cavitation. This can occur when the absolute pressure falls to values likely to allow the formation of vapour bubbles within the fluid whereby the pump works irregularly with reduced head.

All this demostrates the importance of checking that the pump is not producing cavitation because in addition to creating noise like a faulty bearing, cavitation will damage the impeller in a short time.

A special formula associates the value of NPSH required by the pump with the conditions of the installation and with the type of liquid, allowing calculation of the minimum pressure required at the suction and consequently to determine the position in which to locate the pump in relation to the free surface of the liquid to be pumped.

The general formula of N.P.S.H. is:

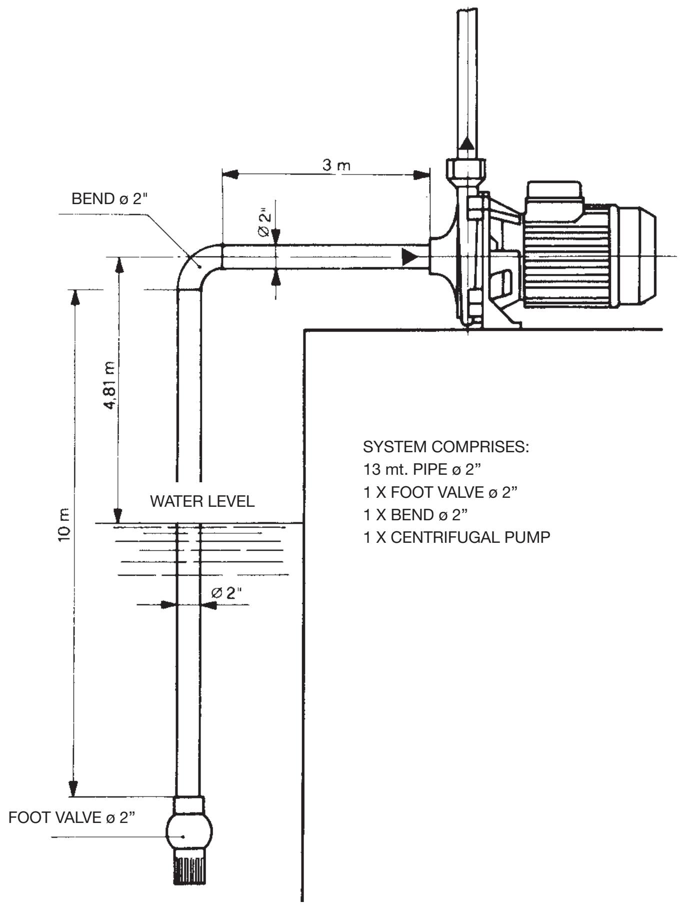
$$NPSH = Z1 + \left(\frac{p1 + pb - pv}{\gamma} \times 10\right) - Hr$$

$$Z1 = NPSH - \left(\frac{p1 + pb - pv}{\gamma} \times 10\right) + Hr$$

where:

Z1 = the difference in level (in m) between the axis of the pump and the free surface of the liquid to be pumped.
p1 = the possible pressure (in kg/cm^2) on the surface of the liquid in the tank from which it is to be pumped. If the suction is from an open tank and the surface of the liquid is in contact with the air, p1 = 0.
pb = atmospheric pressure (in kg/cm^2) at the site of the installation.
pv = the vapour tension (in kg/cm^2) of the liquid at pumping temperature the specific weight (in kg/dm^3) of the liquid at pumping temperature.
γ = the specific weight (in kg/dm^2) of the liquid at pumping temperature.
10 = conversion factor due to the units of measure used.
Hr = head loss (in m) in the suction pipework.

To give a practical example, the diagram below is of an installation for a centrifugal pump which is required to pump a flow Q of 235 l/min under four different conditions.



Calculation of the head loss in the suction pipe (Hr)

Flow	: Q =	235 l/min =	$0{,}00392\ m^3/s$	
Cross sectional area of 2" pipe	: S =	$19{,}6\ cm^2$ =	$0{,}00196\ m^2$	
Velocity of water in pipe	: V =	Q/S	$\frac{0{,}00392}{0{,}00196}$	= 2 m/s

The head losses (see tables 1 & 2):

- 2" foot valve	=	0,610 m
- curves (assume. $\frac{d}{R} = 1$)	=	0,058 m
- suction piping (10 m + 3 m)	=	1,370 m
- total loss suction	=	2,040 m

Let us now consider the four different conditions under which the pump is required to operate. We shall assume that the required NPHS for the required head is 3.25m. The atmospheric pressure pb is read from the table on page 12, the vapour tension and specific weight are read from table 3 and the loss in the suction is as calculated above.

1st case: installation at sea level and water at 20°C.

$$3{,}25 = Z1 + \left(\frac{1{,}033 - 0{,}0238}{0{,}9982} x\ 10\right) - 2{,}04$$

$$Z1 = 3{,}25 - \left(\frac{1{,}033 - 0{,}0238}{0{,}9982} x\ 10\right) + 2{,}04 = -\ 4{,}82$$

which means that the pump, for the flow being considered, can pump water at 20° from a maximum depth of 4.82m. It must be observed that a flow of greater than 235 l/min increases the value of the NPHS of the pump and the head loss in the suction pipework. Consequently the available suction head will be less than 4.82m. The opposite happens for flows of less than 235 l/min and form this it follows that to bring the pump back to regular functioning, it is often sufficient to partially close the discharge valve there reducting the flow.

2nd case: installation at sea level and water at 60°C

$$3{,}25 = Z1 + \left(\frac{1{,}033 - 0{,}2031}{0{,}9831} x\ 10\right) - 2{,}04$$

$$Z1 = 3{,}25 - \left(\frac{1{,}033 - 0{,}2031}{0{,}9831} x\ 10\right) + 2{,}04 = -\ 3{,}15$$

which means that the pump, for the flow being considered, can pump water at 60°C from a maximum depht of 3.15m.

3rd case: installation at sea level and water at 90°C

$$3{,}25 = Z1 + \left(\frac{1{,}033 - 0{,}7149}{0{,}9653} x\ 10\right) - 2{,}04$$

$$Z1 = 3{,}25 - \left(\frac{1{,}033 - 0{,}7149}{0{,}9653} x\ 10\right) + 2{,}04 = -\ 1{,}99$$

which means that the free surface of the water at 90°C must be at least 1.99m above the axis of the pump.

4th case: installation at 1500mabove sea level and water at 50°C.

$$3{,}25 = Z1 + \left(\frac{0{,}860 - 0{,}1258}{0{,}9880} x\ 10\right) - 2{,}04$$

$$Z1 = 3{,}25 - \left(\frac{0{,}860 - 0{,}1258}{0{,}9880} x\ 10\right) + 2{,}04 = -\ 2{,}14$$

which means that the pump, for the flow being considered, can pump water at 50°C from a maximum depht of 2.14m when installed at 1500m above sea level.

N.B.: it's always wise to include a safety margin (0.5m for cold water) to allow for errors and unforeseen variations in the estimated values. i.e. natural variation in atmospherical pressure. Such a margin is even more important with liquids near to boiling point as small temperature changes can produce large differences in operating conditions. For example in case 3, if the temperature of the water were to reach 95°C, the neccessary head wold increase from 1.99m to 3.51m.

NOTES ON THE MOTORS OF ELCTRIC PUMPS

INDEX OF SYMBOLS USED		
P_1	=	power absorbed by the motor kW
P_2	=	power absorbed by the motor in kW or HP
V ~	=	AC voltage of the mains
Hz	=	frequency in cycles per second of the mains supply
I	=	current drawn by the motor in Amps
$\cos\varphi$	=	power factor
$\mathbf{n}^{1/min}$	=	speed of rotation in rpm
η	=	output power (relation between developed power and absorbed power P_2/P_1)
p	=	number of poles of the motor
Cn	=	nominal torque of the motor

Speed of rotation at no load

The no-load speed of electric induction motors, single and three phase, is given by the formula:

$$\mathbf{n}^{1/min} = \frac{120 \times Hz}{p}$$

No-load speed of rotation $\mathbf{n}^{1/min}$

FREQUENCY Hz	2 POLES	4 POLES
50	3000	1500
60	3600	1800

The speed at full load is lower by 2% to 7% than at no load.

Current absorbed

single-phase : $I = \frac{1000 \times P_2 \text{ (kW)}}{V \times \cos\varphi \times \eta}$ or $I = \frac{736 \times P_2 \text{ (HP)}}{V \times \cos\varphi \times \eta}$

three-phase : $I = \frac{1000 \times P_2 \text{ (kW)}}{1.73 \times V \times \cos\varphi \times \eta}$ or $I = \frac{736 \times P_2 \text{ (HP)}}{1.73 \times V \times \cos\varphi \times \eta}$

Power absorber

single-phase : $P_1 \text{ (kW)} = \frac{V \times I \times \cos\varphi}{1000}$

three-phase : $P_1 \text{ (kW)} = \frac{1.73 \times V \times I \times \cos\varphi}{1000}$

Power developed at the motor axis

single-phase : $P_2 \text{ (kW)} = \frac{V \times I \times \cos\varphi \times \eta}{1000}$ or : $P_2 \text{ (HP)} = \frac{V \times I \times \cos\varphi \times \eta}{736}$

three-phase : $P_2 \text{ (kW)} = \frac{1.73 \times V \times I \times \cos\varphi \times \eta}{1000}$ or : $P_2 \text{ (HP)} = \frac{1.73 \times V \times I \times \cos\varphi \times \eta}{736}$

Output

$$\eta = \frac{P_2 \text{ (kW)}}{P_1 \text{ (kW)}}$$

Power factor

single-phase : $\cos\varphi = \dfrac{P_2\,(kW) \times 1000}{V \times I \times \eta}$ = or : $\cos\varphi = \dfrac{P_1\,(kW) \times 1000}{V \times I}$

three-phase : $\cos\varphi = \dfrac{P_2\,(kW) \times 1000}{1.73 \times V \times I \times \eta}$ = or : $\cos\varphi = \dfrac{P_1\,(kW) \times 1000}{1.73 \times V \times I}$

Torque factor

$Cn = \dfrac{P_2\,(kW) \times 1000}{1.027 \times \mathbf{n}^{1/min}}$ in Kgm

$Cn = \dfrac{P_2\,(HP) \times 736}{1.027 \times \mathbf{n}^{1/min}}$ in Kgm

$Cn = \dfrac{702 \times HP}{\mathbf{n}^{1/min}}$ in decaNewtonmetres

Relationship between kW and HP

1 HP = 0.736 kW   1 kW = 1.36 HP $\dfrac{HP}{1.36}$ = kW   kW x 1,36 = HP

Starting current (Isp)

The starting current (at swich on) of a motor is greater than the full load current by between 4 to 8 times

$Isp = In \times 4 \div 8$

Details on capacitors

The approximate current absorbed by a capacitor is:

$I = \dfrac{6{,}28 \times F \times C \times V}{1.000.000}$

Where:

I = current in Amps drawn by the capacitor
F = frequency in Hz of the voltage applied
C = capacity of capacitor µF
V = applied voltage

Example:
The current absorbed by a capacitor which of 14 µF connected to a supply of 220 Volt - 50 Hz, is:

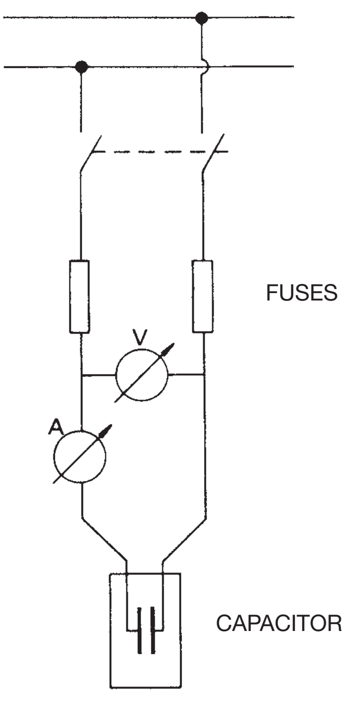
$I = \dfrac{6{,}28 \times 50 \times 14 \times 220}{1.000.000} = 0{,}96$ Amperes

The approximate flow of a capacitor is determined by:

$C = \dfrac{I}{6{,}28 \times F \times V} \times 1.000.000$

Example:
The capacity of a capacitor which absorb 1,4 Amps connected to a supply of 220 Volt - 50 Hz, is:

$C = \dfrac{1{,}4}{6{,}28 \times 50 \times 220} \times 1.000.000 = 20{,}2\ \mu F$



Star-delta starting

A motor which runs connected in delta Δ is started connected in star ⅄ .
The current and the starting torque are reduced to one third of the value they wold be starting in delta Δ.

Protection

It’s advisable to connected electric motors to the supply by a suitable contactor starter with appropriated overload.

HEAD LOSS

in cm of column of water per metre of straight pipework

TAB. 1

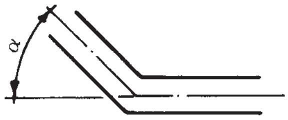
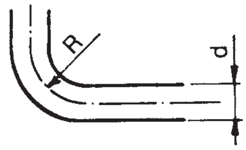
v	Q h	DIAMETER OF PIPE IN mm.																	
		20	**25**	**30**	**40**	**50**	**65**	**80**	**100**	**125**	**150**	**175**	**200**	**250**	**300**	**350**	**400**	**450**	**500**
0,5	Q	9,4	14,7	21,2	37,7	59,0	115	151	235	369	530	723	940	1480	2120	2880	3770	4780	5890
	h	**2,4**	**1,9**	**1,5**	**1,0**	**0,8**	**0,56**	**0,46**	**0,36**	**0,28**	**0,23**	**0,19**	**0,16**	**0,13**	**0,105**	**0,089**	**0,076**	**0,067**	**0,06**
0,6	Q	11,3	17,7	25,4	45,3	70,7	138	181	282	442	636	887	1130	1770	2540	3460	4520	5730	7060
	h	**3,3**	**2,6**	**2,1**	**1,5**	**1,12**	**0,78**	**0,65**	**0,5**	**0,39**	**0,32**	**0,27**	**0,23**	**0,18**	**0,15**	**0,12**	**0,11**	**0,096**	**0,086**
0,7	Q	13,2	20,6	29,7	52,9	82,5	161	211	329	516	742	1010	1315	2070	2960	4040	5270	6690	8250
	h	**4,4**	**3,4**	**2,7**	**1,9**	**1,5**	**1,0**	**0,86**	**0,67**	**0,52**	**0,43**	**0,36**	**0,31**	**0,24**	**0,2**	**0,17**	**0,15**	**0,13**	**0,12**
0,8	Q	15,05	23,6	33,9	60,4	94,5	184	241	377	590	848	1155	1505	2360	3390	4620	6030	7650	9420
	h	**5,6**	**4,3**	**3,4**	**2,5**	**1,9**	**1,3**	**1,1**	**0,86**	**0,67**	**0,55**	**0,46**	**0,4**	**0,31**	**0,26**	**0,22**	**0,19**	**0,17**	**0,15**
0,9	Q	16,95	26,5	38,2	68,0	106,0	207	272	423	664	955	1300	1695	2660	3810	5200	6780	8600	10600
	h	**6,9**	**5,3**	**4,3**	**3,0**	**2,4**	**1,7**	**1,4**	**1,1**	**0,84**	**0,69**	**0,58**	**0,5**	**0,39**	**0,32**	**0,27**	**0,24**	**0,21**	**0,19**
1,0	Q	18,8	29,5	42,4	75,5	117,7	230	302	471	737	1060	1445	1880	2950	4230	5770	7530	9550	11770
	h	**8,3**	**6,4**	**5,1**	**3,7**	**2,9**	**2,1**	**1,7**	**1,3**	**1,0**	**0,84**	**0,71**	**0,61**	**0,48**	**0,4**	**0,34**	**0,29**	**0,26**	**0,23**
1,1	Q	20,7	32,4	46,6	83,0	129,5	252	332	518	81	1165	1585	2070	3250	4650	6350	8290	10500	12950
	h	**9,9**	**7,6**	**6,2**	**4,4**	**3,4**	**2,4**	**2,0**	**1,6**	**1,2**	**1,0**	**0,85**	**0,74**	**0,58**	**0,48**	**0,4**	**0,35**	**0,31**	**0,28**
1,2	Q	22,6	35,4	50,9	90,6	141,0	276	362	565	885	1272	1730	2260	3550	5080	6930	9040	11450	14140
	h	**11,7**	**9,0**	**7,2**	**5,2**	**4,0**	**2,9**	**2,4**	**1,9**	**1,5**	**1,2**	**1,0**	**0,87**	**0,69**	**0,56**	**0,48**	**0,42**	**0,37**	**0,32**
1,3	Q	24,5	38,3	55,0	98,0	153,0	299	392	612	960	1378	1875	2450	3840	5500	7500	9800	12400	15320
	h	**13,5**	**10,4**	**8,4**	**6,0**	**4,7**	**3,3**	**2,8**	**2,2**	**1,71**	**1,4**	**1,15**	**1,0**	**0,8**	**0,66**	**0,56**	**0,49**	**0,43**	**0,38**
1,4	Q	26,35	41,3	59,3	105,5	165,0	302	422	660	1032	1473	2020	2635	4140	5920	8090	10530	13370	16500
	h	**15,4**	**11,9**	**9,6**	**6,9**	**5,4**	**3,8**	**3,2**	**2,5**	**2,0**	**1,6**	**1,3**	**1,17**	**0,92**	**0,76**	**0,64**	**0,56**	**0,5**	**0,44**
1,5	Q	28,25	44,2	63,6	113,0	176,5	345	452	707	1106	1590	2165	2825	4430	6350	8660	11300	14320	17680
	h	**17,4**	**13,5**	**10,9**	**7,8**	**6,1**	**4,4**	**3,6**	**2,8**	**2,25**	**1,82**	**1,5**	**1,34**	**1,05**	**0,87**	**0,74**	**0,64**	**0,57**	**0,51**
1,6	Q	30,1	47,1	67,8	121,0	188,5	368	483	753	1180	1695	2310	3010	4730	6770	9240	12055	5015270	18850
	h	**19,6**	**15,3**	**12,4**	**8,9**	**6,9**	**4,9**	**4,1**	**3,2**	**2,55**	**2,05**	**1,7**	**1,53**	**1,18**	**0,99**	**0,84**	**0,72**	**0,64**	**0,58**
1,7	Q	32,0	50,1	72,0	128,0	200,0	392	513	800	1253	1802	2455	3200	5020	7190	9820	12800	16230	20030
	h	**21,9**	**17,2**	**13,9**	**10,0**	**7,8**	**5,4**	**4,6**	**3,6**	**2,85**	**2,3**	**1,95**	**1,7**	**1,33**	**1,11**	**0,94**	**0,81**	**0,73**	**0,65**
1,8	Q	33,9	53,0	76,3	136,0	212,0	415	543	848	1327	1905	2600	3390	5320	7610	10380	13550	17200	21200
	h	**24,2**	**19,1**	**15,4**	**11,1**	**8,7**	**6,0**	**5,1**	**4,0**	**3,15**	**2,6**	**2,2**	**1,9**	**1,48**	**1,24**	**1,05**	**0,91**	**0,81**	**0,73**
1,9	Q	35,8	56,0	80,5	143,5	224,0	438	573	895	1400	2015	2740	3580	5610	8040	10960	14300	18150	22400
	h	**26,8**	**21,0**	**17,0**	**12,3**	**9,6**	**6,8**	**5,6**	**4,4**	**3,45**	**2,85**	**2,45**	**2,1**	**1,64**	**1,38**	**1,17**	**1,01**	**0,9**	**0,81**
2,0	Q	37,7	59,0	84,8	151,0	235,5	461	603	943	1475	2120	2885	3765	5910	8460	11540	15060	19100	23570
	h	**29,6**	**23,0**	**18,6**	**13,4**	**10,5**	**7,5**	**6,2**	**4,9**	**3,8**	**3,17**	**2,7**	**2,33**	**1**	**1,52**	**1,3**	**1,12**	**0,99**	**0,89**
2,1	Q	39,5	62,0	89,0	158,5	247,5	484	633	990	1548	225	3030	3955	6200	8890	12100	15810	20050	24750
	h	**32,2**	**25,1**	**20,4**	**14,8**	**11,5**	**8,2**	**6,8**	**5,4**	**4,2**	**3,5**	**2,95**	**2,55**	**2,0**	**1,68**	**1,43**	**1,22**	**1,08**	**0,98**
2,2	Q	41,5	64,9	93,2	176,0	259,0	507	663	1036	1620	2330	3175	4145	6500	9300	12700	16570	21000	25930
	h	**35,0**	**27,3**	**22,3**	**16,2**	**12,5**	**9,1**	**7,4**	**5,9**	**4,6**	**3,85**	**3,25**	**2,8**	**22**	**1,85**	**1,56**	**1,34**	**1,18**	**1,08**
2,3	Q	43,3	67,9	97,5	173,5	271,0	530	694	1082	1695	2440	3320	4330	6800	9730	13270	17310	21950	27100
	h	**38,0**	**29,7**	**24,2**	**17,7**	**13,6**	**9,8**	**8,1**	**6,4**	**5,0**	**4,15**	**3,5**	**3,05**	**2,4**	**2,03**	**1,7**	**1,46**	**1,28**	**1,18**
2,4	Q	45,2	70,8	101,5	181,0	282,5	553	724	1130	1770	2545	3460	4520	7090	10140	13850	18090	22900	28300
	h	**42,1**	**32,1**	**26,2**	**19,1**	**14,7**	**10,6**	**8,8**	**6,9**	**5,45**	**455**	**3,8**	**3,3**	**2,62**	**2,21**	**1,85**	**1,58**	**1,38**	**1,28**
2,5	Q	47,1	73,7	105,8	189,0	294,5	576	755	1178	1843	2650	3610	4710	7390	10570	14420	18820	23880	29450
	h	**45,0**	**34,7**	**28,3**	**20,5**	**16,0**	**11,4**	**9,6**	**7,5**	**5,9**	**4,9**	**4,1**	**3,58**	**2,84**	**2,4**	**2,0**	**1,7**	**1,5**	**1,4**
2,6	Q	49,0	76,6	110,0	196,0	306,0	599	785	1225	1915	2755	3755	4900	7680	11000	15000	19590	24820	30630
	h	**48,3**	**37,3**	**30,4**	**22,2**	**17,2**	**12,3**	**10,4**	**8,1**	**6,35**	**5,25**	**4,4**	**3,85**	**3,07**	**2,59**	**2,17**	**1,84**	**1,62**	**1,51**
2,7	Q	50,9	79,6	114,3	204,0	318,0	622	815	1271	1990	2860	3900	5090	7980	111410	15590	20340	25800	31820
	h	**51,7**	**40,0**	**32,5**	**23,8**	**18,5**	**13,2**	**11,2**	**8,7**	**6,85**	**5,65**	**4,75**	**4,15**	**3,3**	**2,78**	**2,34**	**1,98**	**1,74**	**1,62**
2,8	Q	52,7	82,6	118,5	211,5	330,0	645	845	1320	2060	2970	4040	5280	8270	11830	16160	21090	26730	33000
	h	**55,2**	**42,5**	**34,8**	**25,5**	**19,9**	**14,0**	**12,0**	**9,3**	**7,35**	**6,05**	**5,10**	**4,45**	**3,56**	**2,98**	**2,51**	**2,13**	**1,88**	**1,74**
2,9	Q	54,6	85,5	123,0	219,0	342,0	668	875	1365	2140	3075	4190	5460	8560	12250	16730	21480	27700	34200
	h	**58,7**	**45,1**	**37,1**	**27,1**	**21,3**	**15,2**	**12,8**	**10,0**	**7,85**	**6,45**	**5,5**	**4,75**	**3,82**	**3,18**	**2,7**	**2,3**	**2,03**	**1,87**
3,0	Q	56,5	88,5	127,0	226,5	354,0	691	905	1414	2210	3180	4330	5650	8850	12690	17310	22600	28650	35350
	h	**62,9**	**47,9**	**39,6**	**28,8**	**22,6**	**16,3**	**13,6**	**10,7**	**8,4**	**6,9**	**5,9**	**5,1**	**4,1**	**3,4**	**2,9**	**2,5**	**2,2**	**2,0**

see note opposite

HEAD LOSS

in cm column of water in bends, gate valves and foot valves

TAB. 2

Velocity of water in m/s	SHARP EDGED BENDS					NORMAL BENDS					Gate Valve	Foot Valve	Non-return Valve	Head loss on exit from pipes V^2:2g
														
	α = 30°	α = 40°	α = 60°	α = 80°	α = 90°	$\frac{d}{R}$ = 0,4	$\frac{d}{R}$ = 0,6	$\frac{d}{R}$ = 0,8	$\frac{d}{R}$ = 1	$\frac{d}{R}$ = 1,5				
0,10	0,03	0,04	0,05	0,07	008	0,07	0,08	0,01	0,0155	0,027	0,03	30	30	0,05
0,15	0,06	0,73	0,1	0,14	0,17	0,016	0,019	0,024	0,033	0,06	0,033	31	31	0,12
0,2	0,11	0,13	0,18	0,26	0,31	0,028	0,033	0,04	0,059	0,11	0,058	31	31	0,21
0,25	0,17	0,21	0,28	0,4	0,48	0,044	0,052	0,063	0,091	0,17	0,09	31	31	0,32
0,3	0,25	0,3	0,41	0,6	0,7	0,063	0,074	0,09	0,13	0,25	0,13	31	31	0,46
0,35	0,33	0,4	0,54	0,8	0,93	0,085	0,10	0,12	0,18	0,33	0,18	31	31	0,62
0,14	0,43	0,52	0,71	1,0	1,2	0,11	0,13	0,16	0,23	0,43	0,23	32	31	0,82
0,5	0,67	0,81	1,1	1,6	1,9	0,18	0,21	0,26	0,37	0,67	0,37	33	32	1,27
0,6	0,97	1,2	1,6	2,3	2,8	0,25	0,29	0,36	0,52	0,97	0,52	34	32	1,84
0,7	1,35	1,65	2,2	3,2	3,9	0,34	0,40	0,48	0,70	1,35	0,7	35	32	2,5
0,8	1,7	2,1	2,8	4,0	4,8	0,45	0,53	0,64	0,93	1,7	0,95	36	33	3,3
0,9	2,2	2,7	6	5,2	6,2	0,57	0,67	0,82	1,18	2,2	1,2	37	34	4,2
1,0	2,7	3,3	4,5	6,4	7,6	0,7	0,82	1,0	1,45	2,7	1,45	38	35	5,1
1,5	6,0	7,3	10,0	14,0	17,0	1,6	1,9	2,3	3,3	6,0	3,3	47	40	11,5
2,0	11,0	14,0	18,0	26,0	31,0	2,8	3,3	4,0	5,8	11,0	5,8	61	48	20,4
2,5	17,0	21,0	28,0	40,0	48,0	4,4	5,2	6,3	9,1	17,0	9,1	78	58	32,0
3,0	25,0	30,0	41,0	60,0	70,0	6,3	7,4	9,0	13,0	25,0	13,0	100	71	46,0
3,5	33,0	40,0	55,0	78,0	93,0	8,5	10,0	12,0	18,0	33,0	18,0	123	85	62,0
4,0	43,0	52,0	70,0	100,0	120,0	11,0	13,0	16,0	23,0	42,0	23,0	150	100	82,0
4,5	55,0	67,0	90,0	130,0	160,0	14,0	21,0	26,0	37,0	55,0	37,0	190	120	103,0
5,0	67,0	82,0	110,0	160,0	190,0	18,0	29,0	36,0	52,0	67,0	52,0	220	140	127,0

NOTES

Q = flow in l/min
v = velocity of water in m/s
d = diameter of pipes in m
h = head loss in cm water for each meter of pipe column calculated according to the Lang formula where :

$$h = \lambda \times \frac{100}{d} \times \frac{v^2}{2g} \qquad \lambda = 0,02 + \frac{0,0018}{\sqrt{v \times d}}$$

The head loss in curves is only that due to the contraction of the stream of liquid in chaning direction. The development of the curves must therefore be included in the length of the pipework. The head loos for valves has been determined on the basis of technical experimentation.
The head losses for gate valves and normal bends is equivalent to that of 5m of straight pipe, whilst that of non-return valves is equivalent to 15 m.
The valves given are for pipes with a smooth bore. In the case of rought or scaled pipes it will be necessary to make the relevent allowances.

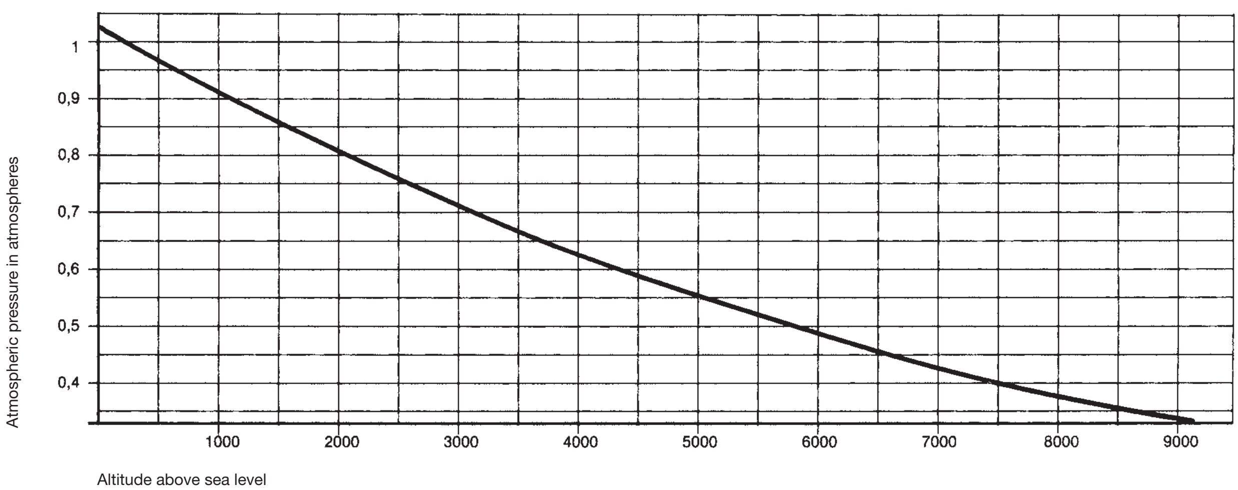
PRESSURE DROPS MUST BE MULTIPLIED: BY 0.8 (STAINLESS STEEL PIPES); BY 1.25 (SLIGHTLY RUSTY STEEL PIPES); BY 1.7 (ENCRUSTED PIPES WITH REDUCED INTERNAL DIAMETERS); BY 0.7 (ALUMINIUM PIPES); BY 0.7 (PVC AND PE PIPES); BY 1.3 (FIBRE-CEMENT PIPES).

Vapour tension and specific weight of water as a function of temperature

TAB. 3

t °C	*pv* kg/cm²	γ kg/dm³	*t* °C	*pv* kg/cm²	γ kg/dm³	*t* °C	*pv* kg/cm²	γ kg/dm³	*t* °C	*pv* kg/cm²	γ kg/dm³
0	0,0062	0,9998	41	0,793	0,9917	82	0,5234	0,9705	170	8,076	0,8973
1	0,0067	0,9999	42	0,836	0,9913	83	0,5447	0,9698	175	9,101	0,8920
2	0,0072	0,9999	43	0,0881	0,9909	84	0,5667	0,9693	180	10,225	0,8869
3	0,0077	1,0000	44	0,0928	0,9905	85	0,5897	0,9687	185	11,456	0,8814
4	0,0083	1,0000	45	0,0977	0,9900	86	0,6129	0,9680	190	12,800	0,8760
5	0,0089	1,0000	46	0,1028	0,9898	87	0,6372	0,9673	195	14,265	0,8703
6	0,0095	0,9999	47	0,1082	0,9883	88	0,6623	0,9667	200	15,857	0,8646
7	0,0102	0,9999	48	0,1138	0,9889	89	0,6882	0,9659	205	17,858	0,8587
8	0,0109	0,9998	49	0,1197	0,9885	90	0,7149	0,9653	210	19,456	0,8528
9	0,0117	0,9997	50	0,1258	0,9880	91	0,7425	0,9646	215	21,477	0,8465
10	0,0125	0,9996	51	0,1322	0,9876	92	0,7710	0,9640	220	23,659	0,8403
11	0,0134	0,9995	52	0,1388	0,9871	93	0,8004	0,9632	225	26,007	0,8339
12	0,0143	0,9994	53	0,1457	0,9866	94	0,8307	0,9625	230	28,531	0,8272
13	0,0153	0,9993	54	0,1530	0,9861	95	0,8619	0,9619	235	31,239	0,8206
14	0,0163	0,9992	55	0,1605	0,9857	96	0,8942	0,9611	240	34,140	0,8136
15	0,0174	0,9990	56	0,1683	0,9852	97	0,9271	0,9604	245	37,244	0,8064
16	0,0185	0,9989	57	0,1765	0,9847	98	0,9616	0,9596	250	40,560	0,7992
17	0,0197	0,9987	58	0,1850	0,9842	99	0,9969	0,9590	255	44,100	0,7918
18	0,0210	0,9985	59	0,1939	0,9836	100	1,0032	0,9583	260	47,870	0,7840
19	0,0224	0,9984	60	0,2031	0,9831	102	1,1092	0,9568	265	51,880	0,7759
20	0,0238	0,9982	61	0,2127	0,9826	104	1,1898	0,9554	270	56,140	0,7678
21	0,0253	0,9979	62	0,2227	0,9821	106	1,2751	0,9540	275	60,660	0,7593
22	0,0269	0,9977	63	0,2330	0,9816	108	1,6354	0,9525	280	65,460	0,7506
23	0,0286	0,9974	64	0,2438	0,9810	110	1,4609	0,9510	285	70,540	0,7416
24	0,0304	0,9972	65	0,2550	0,9804	112	1,5618	0,9495	290	75,920	0,7323
25	0,0323	0,9970	66	0,2666	0,9800	114	1,6684	0,9479	286	81,600	0,7227
26	0,0343	0,9966	67	0,2787	0,9794	116	1,7809	0,9464	300	87,610	0,7214
27	0,0363	0,9964	68	0,2912	0,9788	118	1,8995	0,9448	305	93,950	0,7017
28	0,0385	0,9961	69	0,3042	0,9782	120	2,0245	0,9431	310	100,640	0,6906
29	0,0408	0,9957	70	0,3177	0,9777	122	2,1561	0,9414	315	107,690	0,6793
30	0,0432	0,9955	71	0,3317	0,9771	124	2,2947	0,9398	320	115,130	0,6671
31	0,0458	0,9952	72	0,3463	0,9765	126	2,4404	0,9381	325	122,950	0,6540
32	0,0485	0,9949	73	0,3613	0,9759	128	2,5935	0,9365	330	131,180	0,6402
33	0,0513	0,9946	74	0,3869	0,9754	130	2,7544	0,9348	335	139,850	0,6257
34	0,0542	0,9942	75	0,3931	0,9748	135	3,1920	0,9305	340	148,960	0,6093
35	0,0573	0,9939	76	0,4098	0,9742	140	3,6850	0,9260	345	157,540	0,5910
36	0,0606	0,9934	77	0,4274	0,9737	145	4,2370	0,9216	350	168,630	0,5724
37	0,0640	0,9932	78	0,4451	0,9730	150	4,8540	0,9169	355	179,240	0,5512
38	0,0675	0,9928	79	0,4637	0,9724	155	5,5400	0,9121	360	190,420	0,5243
39	0,0713	0,9925	80	0,4829	0,9718	160	6,3020	0,9073	365	202,210	0,4926
40	0,0752	0,9921	81	0,5028	0,9712	165	7,1460	0,9023	370	214,680	0,4484

Atmospheric pressure at varying heights



Flow of water from nozzles and fire hoses, in l/h, as a function of the pressure measured upstream from the nozzle in metres of column of water

Ø nozzle in mm	PRESSURE in m.c.w.												
	4	6	8	10	12	14	16	18	20	22	24	26	28
1	0,0068	0,0083	0,0096	0,0107	0,0118	0,0127	0,0136	0,0144	0,0152	0,0159	0,0167	0,0174	0,018
2	0,273	0,0334	0,0386	0,0432	0,0473	0,0511	0,0546	0,0579	0,0611	0,064	0,0668	0,696	0,0722
3	0,614	0,0751	0,0868	0,097	0,1063	0,1148	0,1228	0,13	0,137	0,144	0,15	0,156	0,162
4	0,109	0,133	0,154	0,175	0,189	0,204	0,218	0,231	0,244	0,255	0,267	0,278	0,288
5	1,171	0,209	0,242	0,271	0,296	0,32	0,342	0,363	0,383	0,401	0,419	0,4336	0,453
6	0,246	0,301	0,348	0,389	0,426	0,455	0,492	0,522	0,55	0,577	0,603	0,627	0,652
7	0,334	0,408	0,472	0,527	0,578	0,625	0,667	0,708	0,747	0,783	0,817	0,851	0,883
8	0,436	0,534	0,616	0,689	0,755	0,815	0,871	0,925	0,975	1,022	1,067	1,11	1,152
9	0,553	0,677	0,782	0,875	0,958	1,035	1,107	1,172	1,236	1,297	1,355	1,41	1,461
10	0,684	0,836	0,966	1,08	1,183	1,27	1,368	1,448	1,523	1,6	1,672	1,742	1,808
11	0,83	1,017	1,173	1,313	1,439	1,555	1,66	1,76	1,855	1,99	2,03	2,117	2,196
12	0,982	1,2	1,387	1,55	1,7	1,87	1,964	2,08	2,19	2,3	2,4	2,5	2,59
13	1,154	1,412	1,63	1,825	2,0	2,16	2,31	2,45	2,58	2,7	2,83	2,94	3,05
14	1,337	1,635	1,89	2,113	2,313	2,5	2,67	2,834	2,99	3,135	3,27	3,41	2,538
15	1,535	1,88	2,17	2,417	2,66	2,87	3,07	3,25	3,43	3,6	3,76	3,91	4,06
16	1,742	2,132	2,464	2,757	3,02	3,26	3,486	3,7	3,9	4,08	4,27	4,45	4,62
17	1,97	2,413	2,787	3,119	3,417	3,686	3,947	4,18	4,41	4,62	4,83	58,025	5,21
18	2,21	2,703	3,125	3,499	3,83	4,13	4,42	4,68	4,94	5,18	5,42	5,64	5,85
20	2,73	3,34	3,86	4,32	4,73	5,11	5,46	5,78	6,11	6,4	6,78	6,96	7,23
22	3,298	4,04	4,66	5,22	5,72	6,17	6,75	7,0	7,48	7,74	8,07	8,4	8,8
25	4,265	5,22	6,02	6,74	7,38	7,87	8,52	9,04	9,53	9,99	10,42	10,85	11,25
26	4,6	5,64	6,5	7,27	7,97	8,61	9,2	9,76	10,28	10,69	11,27	11,71	12,16
28	5,36	6,56	7,56	8,46	9,28	10,2	10,7	11,36	11,9	12,55	13,12	13,64	14,09
32	6,97	8,55	9,85	11,02	12,08	13,05	13,93	14,8	15,6	16,7	17,2	17,79	18,44
35	8,358	10,23	11,8	13,2	14,45	15,6	16,7	17,7	18,68	19,59	20,43	21,26	22,09
45	13,8	16,9	19,5	21,82	23,9	25,84	27,6	29,3	30,9	32,39	33,8	35,2	26,5
55	20,3	25,2	28,5	32,6	35,7	38,6	41,2	44,0	46,1	48,3	50,5	52,6	54,5
65	28,5	34,8	40,2	45,0	49,3	53,4	56,9	60,5	63,6	66,6	69,7	72,6	75,4
75	38,3	46,9	54,2	60,6	66,4	71,7	76,6	81,4	85,6	90,0	93,9	97,7	101,4
85	49,4	60,5	69,7	77,0	85,5	92,4	98,7	104,7	110,3	115,7	121,0	125,0	130,5
95	61,5	75,4	87,0	97,4	106,5	115,2	123,0	130,5	137,6	143,3	150,8	1570,0	162,8

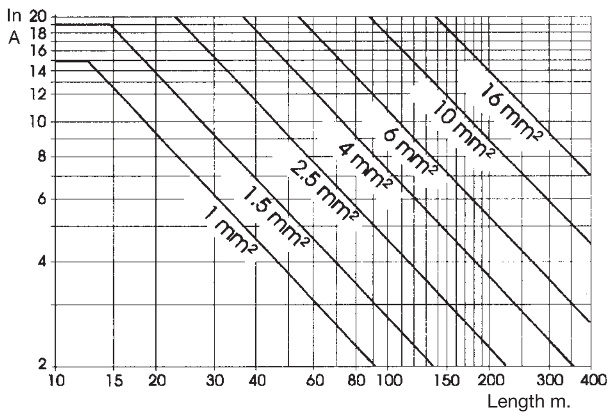
Ø nozzle in mm	PRESSURE in m.c.w.												
	30	35	40	45	50	55	60	65	70	75	80	90	100
1	0,0186	0,0201	0,0216	0,0229	0,0241	0,0252	0,02647	0,0275	0,0285	0,0295	0,0305	0,0324	0,0341
2	0,0748	0,0807	0,0863	0,0916	0,0966	0,1012	0,1058	0,11	0,1142	0,1182	0,122	0,129	0,13695
3	0,168	0,1815	0,194	0,205	0,217	0,227	0,238	0,247	0,256	0,265	0,274	0,291	0,307
4	0,298	0,323	0,344	0,366	0,385	0,404	0,422	0,439	0,456	0,472	0,487	0,516	0,545
5	0,468	0,506	0,542	0,564	0,605	0,635	0,663	0,69	0,716	0,741	0,765	0,812	0,856
6	0,674	0,738	0,778	0,825	0,87	0,913	0,953	0,992	1,03	1,065	1,1	1,168	1,23
7	0,915	0,987	1,055	1,12	1,18	1,238	1,292	1,345	1,394	1,445	1,491	1,584	1,67
8	1,192	1,209	1,375	1,46	1,54	1,615	1,688	1,755	1,822	1,886	1,948	2,063	2,18
9	1,515	1,635	1,749	1,855	1,955	2,05	2,14	2,23	2,32	2,393	2,47	2,62	2,764
10	1,87	2,02	2,16	2,29	2,41	2,53	2,68	2,75	2,86	2,96	3,03	3,24	3,41
11	2,274	2,454	2,624	2,78	2,93	3,08	3,22	3,35	3,47	3,59	3,71	3,94	4,15
12	2,688	2,9	3,1	3,29	3,47	3,64	3,8	3,95	4,1	4,25	4,38	4,65	4,91
13	3,16	3,41	3,65	3,87	4,08	4,28	4,47	4,65	4,83	5,0	5,16	5,47	5,77
14	3,66	3,95	4,23	4,5	4,73	4,96	5,18	5,38	5,59	5,78	5,97	6,34	6,68
15	4,2	4,54	4,75	5,15	5,43	5,69	5,94	6,18	6,43	6,65	6,86	7,28	7,66
16	4,77	5,15	5,52	5,84	6,16	6,46	6,75	7,03	7,3	7,56	7,8	8,26	8,72
17	5,39	5,82	6,22	6,61	6,96	7,3	7,63	7,95	8,24	8,54	8,8	9,35	9,85
18	6,05	6,54	6,99	7,42	7,82	8,2	8,56	8,9	9,24	9,56	9,88	10,48	11,05
20	7,47	8,075	8,63	9,15	9,65	10,12	10,57	11,0	11,4	11,8	12,2	12,94	13,65
22	9,15	9,73	10,3	11,15	11,65	12,2	12,76	13,29	13,79	14,27	14,75	15,62	16,49
25	11,65	12,6	13,45	14,28	15,05	15,78	16,5	17,15	17,8	18,43	19,08	20,2	21,3
26	12,6	13,6	14,55	15,42	16,28	17,05	17,8	18,55	19,24	19,9	20,59	21,8	23,0
28	14,65	15,72	16,93	17,95	18,912	19,85	20,7	21,5	22,4	23,2	23,8	25,4	26,6
32	19,1	20,6	22,04	23,4	24,6	25,09	27,0	28,1	29,2	30,2	31,2	33,1	34,9
35	22,8	24,7	26,4	28,4	29,5	30,9	32,39	33,6	34,9	36,1	37,3	39,6	41,7
45	37,8	40,7	43,6	46,3	48,8	51,2	53,5	55,6	57,87	59,2	61,7	65,6	69,04
55	56,4	60,9	65,2	69,2	72,8	76,4	79,8	83,0	86,2	89,3	92,2	97,8	103,0
65	78,0	84,3	90,0	95,5	100,7	105,6	110,5	114,7	1198,0	123,3	127,4	135,0	142,4
75	105,0	113,3	121,2	128,5	135,6	142,0	148,5	154,5	162,0	166,0	171,2	181,8	191,8
85	135,0	146,0	156,0	165,5	174,5	183,0	191,0	199,0	206,3	213,5	220,5	234,0	246,7
95	168,5	182,0	194,5	206,0	217,6	228,0	238,0	248,0	257,5	266,0	275,0	292,0	307,7

Table of equivalent standards for materials

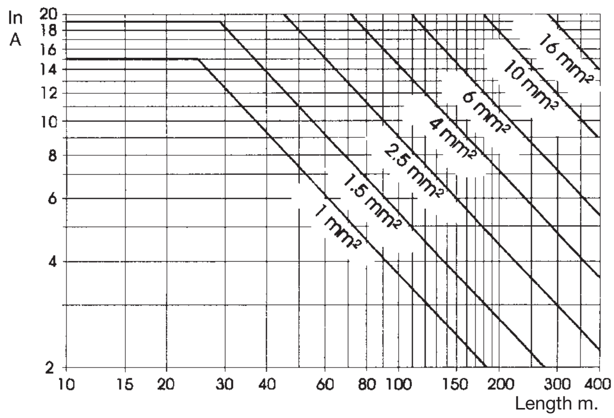
MATERIAL	UNI		DIN		ISO	AISI	ASTM
STEEL	X 30Cr13	UNI 6900/71	X 30Cr13	DIN 17440	–	AISI 420B	–
	X 12CrS13	UNI 6900/71	X 12CrS13	DIN 17440	–	AISI 416	–
	X 20Cr13	UNI 6900/71	X 20Cr13	DIN 17440	–	AISI 420A	S 42000 A 276
	X 10CrNiS1809	UNI 6900/71	X 10CrNiS1809	DIN 17440	XIII-17 ISO 683/XIII	AISI 303	S 30300 A 276
	X 5CrNi 1810	UNI 6900/71	X 5CrNi 1810	DIN 17440	XIII-11 ISO 683/XIII	AISI 304	S 30400 A 276
	X 10CrS17	UNI 6900/71	X 10CrS17	DIN 17440	XIII-84 ISO 683/XIII	AISI 430F	–
CAST IRON	G 20	UNI ISO 185	GG 20	DIN 1691	Grade 20 ISO R 185	–	Class 25 A 48
	G 25	UNI ISO 185	GG 25	DIN 1691	Grade 20 ISO R 185	–	Class 35 A 48
BRASS	G CuZn38Al 1Fe 1Mni	UNI 6138/68	–		–	–	B 30 C 86550
	P CuZn40 Pb2	UNI 5705	P CuZn40 Pb2	DIN 17660	–	–	C 37740
BRONZE	G CuSn12	UNI 7013/72	G CuSn12	DIN 17006	CuSn 12 ISO 1338	–	B 205 C 90700

Cable selection charts

Voltage 1 x 230 V ~ direct start
Volt drop 3%
Ambient temperature 30°C

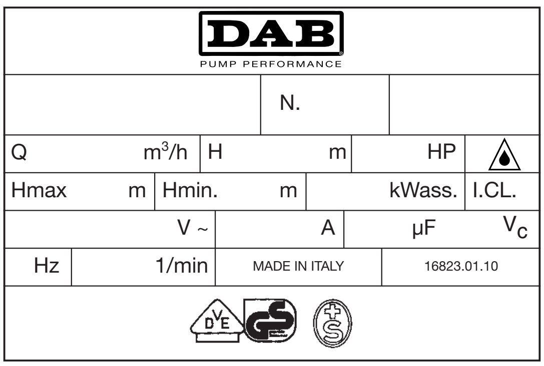


Voltage 3 x 400 V ~ direct start
Volt drop 3%
Ambient temperature 30°C



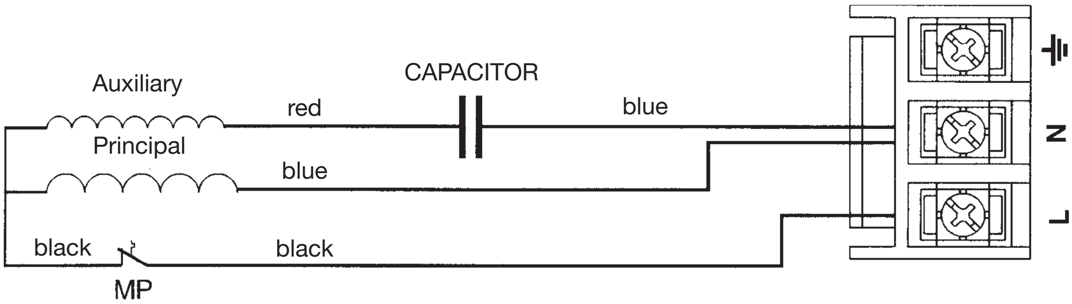
Explanation of pump data plates

N°	SERIAL NUMBER	–
Q	FLOW	m³/h
H	HEAD	m
H max	MAXIMUM HEAD	m
H min	MINIMUM HEAD	m
–	REVOLUTIONS PER MINUTE	1/min
–	ABSORBED POWER	kWass
–	DEVELOPED POWER	HP
–	VOLTAGE	V ~
–	FREQUENCY	Hz
–	CURRENT	A
	DEGREE OF PROTECTION (IEC)	–
I.CL.	INSULATION CLASS	–
–	CAPACITY AND VOLTAGE OF CAPACITOR	μF V_C
m	MAXIMUM IMMERSION	m
	WATERTIGHT WHEN SUBMERGED (IEC)	–

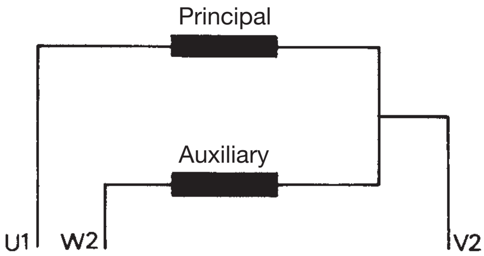


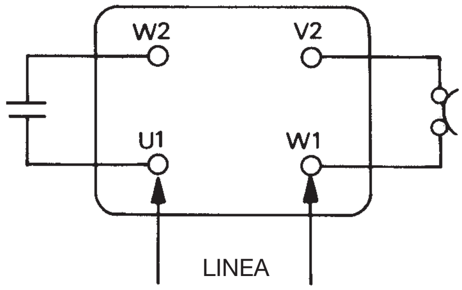
Wiring diagrams for electric motors

SINGLE-PHASE



Overload protection inside the winding - MEC 63-71 M

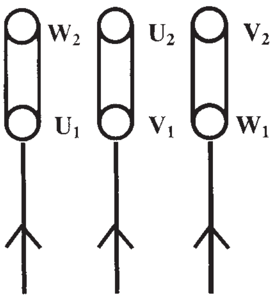


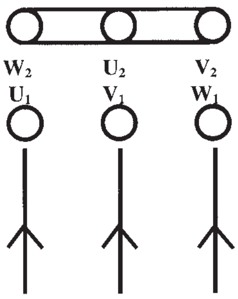


Overload protection inside the terminal board - MEC 80 M

THREE-PHASE

3 ~ 230/400 V

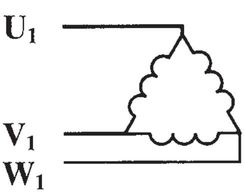




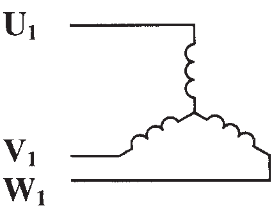
Mains supply
230 V

400 V

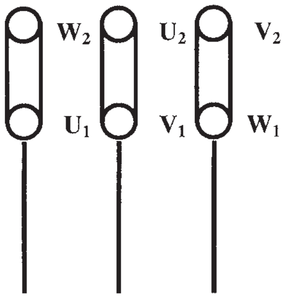
DELTA connection



STAR connection

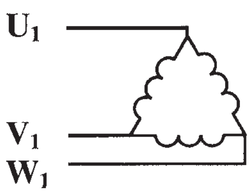


3 ~ 400 Δ V



Mains supply

DELTA connection



All motors rotate clockwise when viewed from the fan end.

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