Hydraulic

Hydraulic is the theory of water flow in conveyors, like canals, pipes etc.
The hydraulic define the different causes influence on the flow:
size of the conveyor, material of the conveyor, the slope, volume of water past in the conveyor, flow velocities, etcetera.
The hydraulic determine the connection between them.
This connection found in hydraulic by mathematics equations.
These hydraulic equations help as to design future water system and to test existing water system.

Pressure and Water-height-column

Pascal (Pa) is the scientific unit of pressure:
One **Pa**scal is equal to a force of one **N**ewton applied to an area of one sq. meter (1N/m^2)
Pressure measures how "concentrated" a force is when it presses on a particular area.
The pressure in a certain point defines as a force activate on a unit area in the same point.

Data:

F = Force (W)

A = Area

P = Pressure

γ = Specific Gravity (of material)

Formulas

$F = P \times A$

$P = F / A = W / A = \gamma \times Vo / A = \gamma \times A \times H / A = \gamma \times H$

$P = \gamma \times H$

Liquid pressure in certain point is:

The specific gravity of the liquid multiply by the liquid height measure perpendicular above the same point.

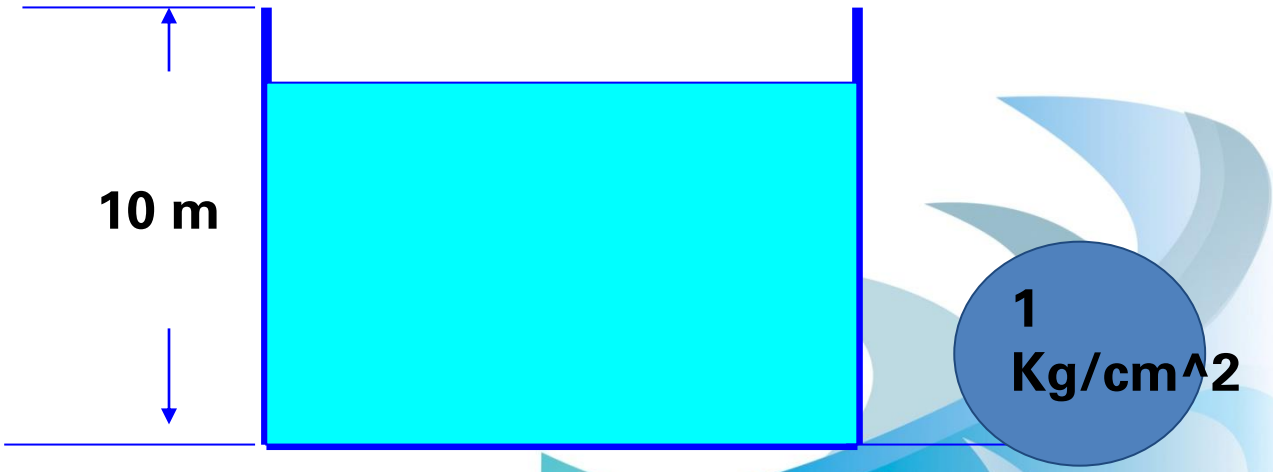
Common Pressure unit:
KPa, ton/m^2, kg/cm^2, m (w.h.c), Atmosphere and bar

Pressure: weight/force perpendicular per area
Head: water height of a vertical column.

10m (w.h.c) = 1kgf/cm^2

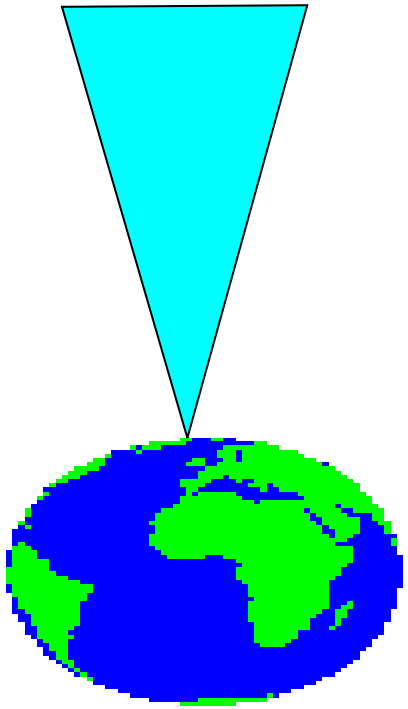
1bar = 100kPa = 1.02kgf/cm^2 = 10.2m (w.h.c) = 14.5PSI

1PSI = 0.069bar = 6.9kPa = 0.07kgf/cm^2 = 0.7m (w.h.c)



ATMOSPERIC PRESSURE

Atmospheric pressure at sea level 1.02Kg/cm^2



Pressure gauge

B.13 Water Flow Velocity (V)

The flow velocity unit, is a speed of water in the conveyor.

Data:

L = Length
T = Time
V = Velocity

Formulas:

V = L / T
L = V x T
1m/sec = 100cm/sec

Water Flow Rate and Quantity (Q)

a. Volume of water per time

b. Water velocity in the conveyor multiply by the cross-section of the water contact in the conveyor.

Data:

Vo = Volume

V = Velocity

T = Time

Q = Flow rate

A = Area cross section

Formulas:

Q = Vo / T

Q = V x A

Vo = Q x T

Common flow rate units:

1m^3/hr.

= 1,000dcm^3/hr. (1,000lit/hr.)
= 1,000,000cm^3/hr. (1,000,000c.c./hr.)
= 1,000,000,000mm^3/hr.

1Lit/sec.

= 1dcm^3/sec.
= 1,000cm^3/sec. (1,000c.c./sec.)
= 1,000,000mm^3/sec.

Head-loss (Friction)

The energy loss or pressure decrease due to friction, when water flow through conveyor.

The velocity of the water has a significant effect on friction loss.

Values for these head loss can calculate by hydraulic equation

Data:

1. Flow-rate: m^3/hr.
2. Length: m.
3. Diameter: mm
4. Material: coefficient friction refer to the table

- To the head-loss, result add. or deducts topographic condition: (+) or (-) m.

Pump station head loss:

Suction system: suction-basket, check-valve, (foot-valve) piping and arches Critical

Delivery system: check-valve, gate-valve, filtration, PR/PS-valve, water-meter Normal

Piping "C" Factor (Friction)

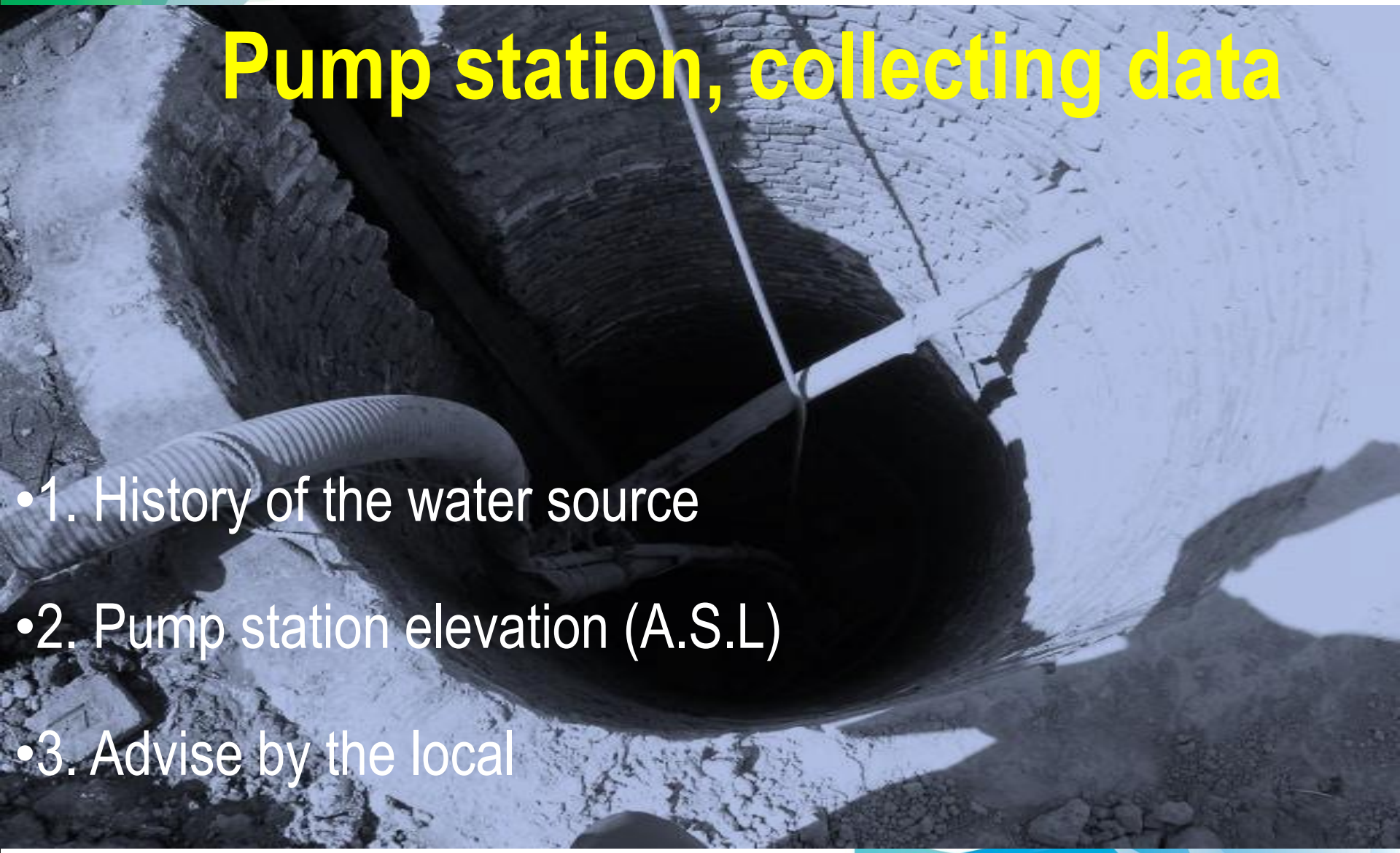
P.V.C = 150
P.E = 140
Steel Iron = 130
Rough Steel Iron = 125 – 100

When the flow rate equal to zero, the head loss will be zero.
When the conveyor length equal to zero, the head loss will be zero.

In hydrostatic position no head loss
However if the velocity increases the head loss also increases.

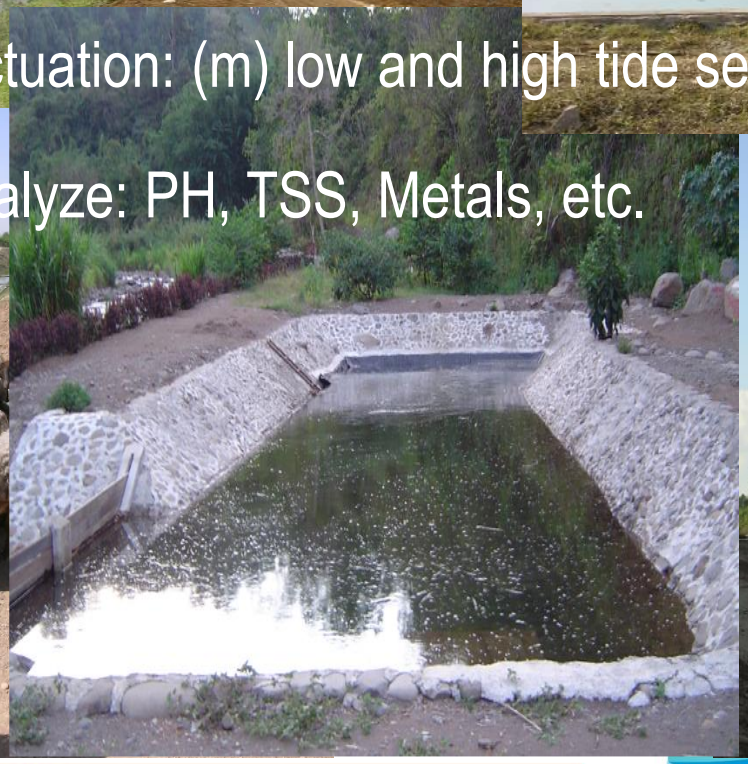
Penjelasan Flow Rate Table Velocity

Pump station, collecting data



- 1. History of the water source
- 2. Pump station elevation (A.S.L)
- 3. Advise by the local

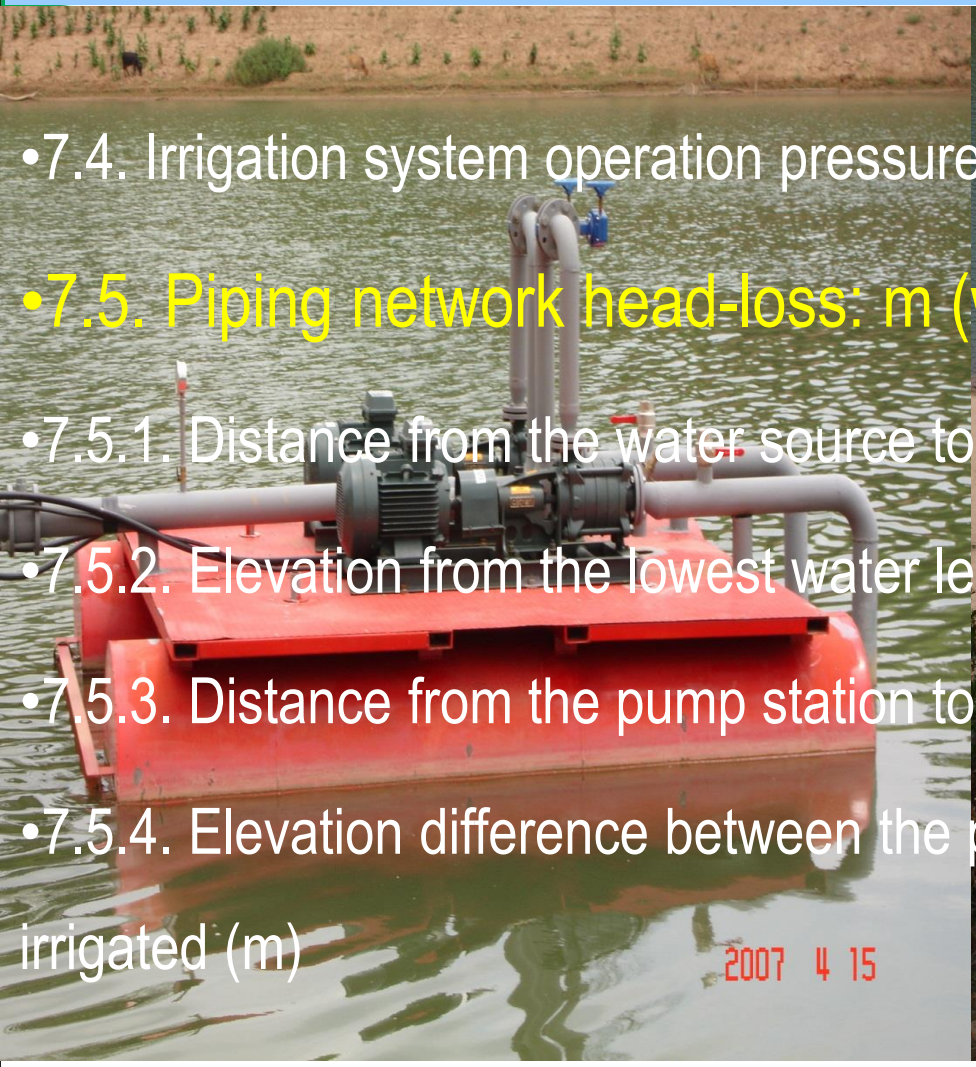
- 4. Type of water source (sub/on surface): Well, river, reservoir, canal etc.
- 5. Water source fluctuation: (m) low and high tide season
- 6. Water sample analyze: PH, TSS, Metals, etc.

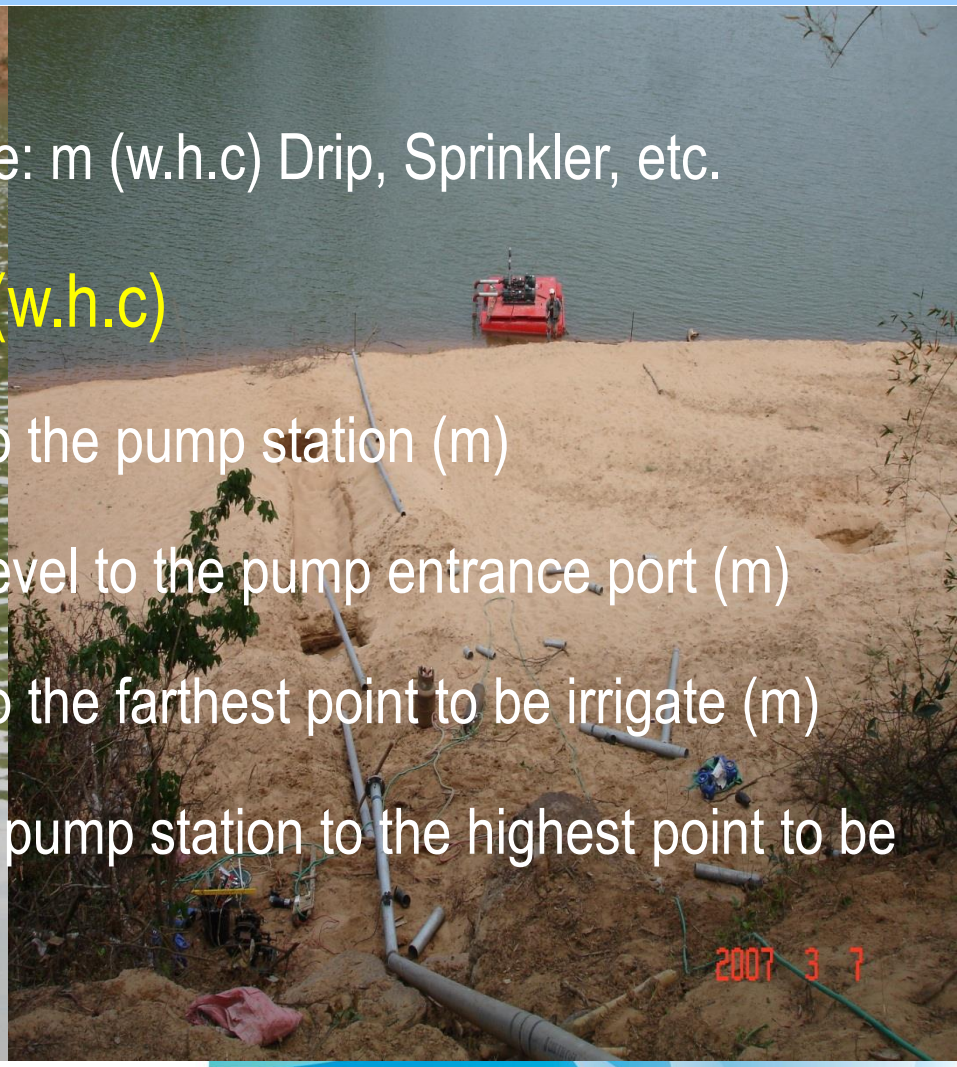


7. Pump flow rate (Q) and total dynamic head (TDH):

- 7.1. Total area to be irrigated: (m^2, Ha, Acre, Rai, Mu, Dunham)
- 7.2. Crop daily consumption: mm/day E.T.
- 7.3. Daily operation duration: hr./day

7. Pump flow rate (Q) and total dynamic head (TDH)





- 7.4. Irrigation system operation pressure: m (w.h.c) Drip, Sprinkler, etc.
- 7.5. Piping network head-loss: m (w.h.c)
- 7.5.1. Distance from the water source to the pump station (m)
- 7.5.2. Elevation from the lowest water level to the pump entrance port (m)
- 7.5.3. Distance from the pump station to the farthest point to be irrigate (m)
- 7.5.4. Elevation difference between the pump station to the highest point to be irrigated (m)

8. Selection an Irrigation pump

8.1. Pumping flow-rate: m^3/hr.

8.2. The total dynamic head: m. (TDH)

8.3. Pump category: Centrifugal, turbine, submersible etc.

8.4. Pump impeller size and amount: mm & stages

8.5. Pump Revolution: 1450, 1750, 2900 and 3500RPM

8.6. Pump ports:

8.6.1. Threaded: BSP, NPT etc.

8.6.2. Flanges: BSTD, DIN, ISO-16, JIS etc.

9. Selecting motor criteria: Electric energy operation

a. Type of electric supply: municipality or generator set
b. How many phases: Single, Triple etc.
c. Voltage operation: 220V~, 380V~ etc.
d. Motor power: KW (HP)
e. Efficiency: xx%
f. Frequency operation: 50Hz or 60Hz
g. Motor-Revolution: 1450, 1750, 2900 and 3500RPM
h. Current required (max.): Ampere (input for electric-panel/transformer)
i. Transformer location: Up to 50m from electric-pump panel
j. Electric cable/poles coast: from municipality to transformer to electric panel
k. Transformer capacity: KVA
l. Energy coast: US$ kw/hr.
m. Weather conditions: temp, moisture etc.

Available motor: kw/HP

- 0.55kw = 0.75HP
- 0.75kw = 1.00HP
- 0.90kw = 1.20HP
- 1.10kw = 1.50HP
- 1.50kw = 2.00HP
- 1.85kw = 2.50HP
- 2.20kw = 3.00HP
- 3.00kw = 4.00HP
- 4.00kw = 5.00HP
- 5.50kw = 7.50HP
- 7.50kw = 10.00HP
- 9.20kw = 12.50HP
- 11.00kw = 15.0HP
- 15.00kw = 20.0HP
- 18.50kw = 25.0HP

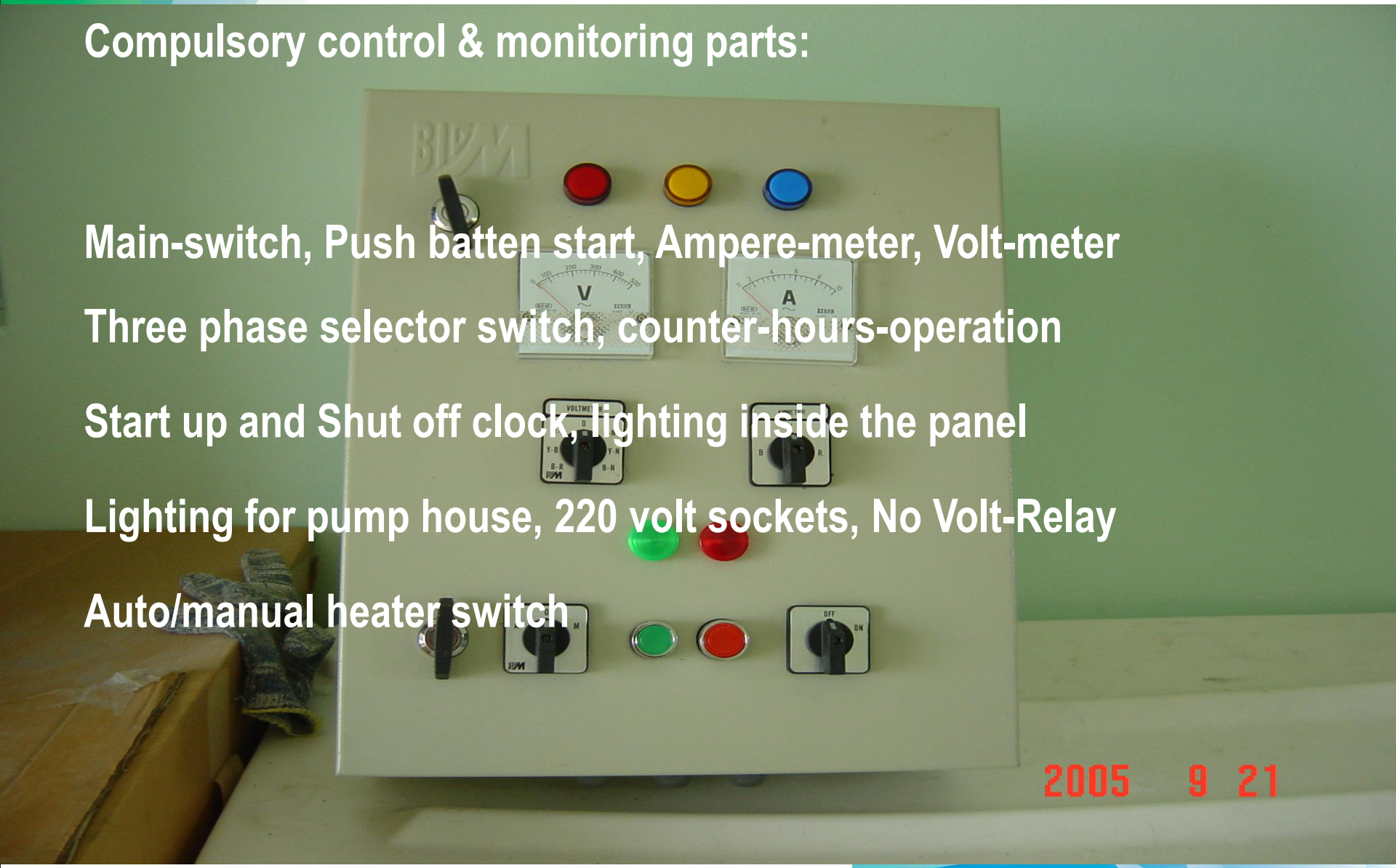
Available motor: kw/HP

- 22.5kw = 30.0HP
- 30.0kw = 40.0HP
- 37.0kw = 50.0HP
- 45.0kw = 60.0HP
- 55.0kw = 75.0HP
- 63.0kw = 85.0HP
- 75.0kw = 100.0HP
- 90.0kw = 120.0HP
- 110.0kw = 150.0HP
- 150.0kw = 200.0HP
- 185.0kw = 250.0HP
- 225.0kw = 300.0HP
- 300.0kw = 400.0HP
- 370.0kw = 500.0HP
- 450.0kw = 600.0HP

10. Selecting an electric control panel criteria:

a. **Voltage operation:** 220V (single phase), 380V (three phase)
b. **Frequency operation:** 50Hz or 60Hz
c. **The required Power:** KW
d. **The required current:** Ampere
e. **Types of starting:** Direct-on-line, Star Delta Start, Autotransformer Start, etc.

Compulsory control & monitoring parts:



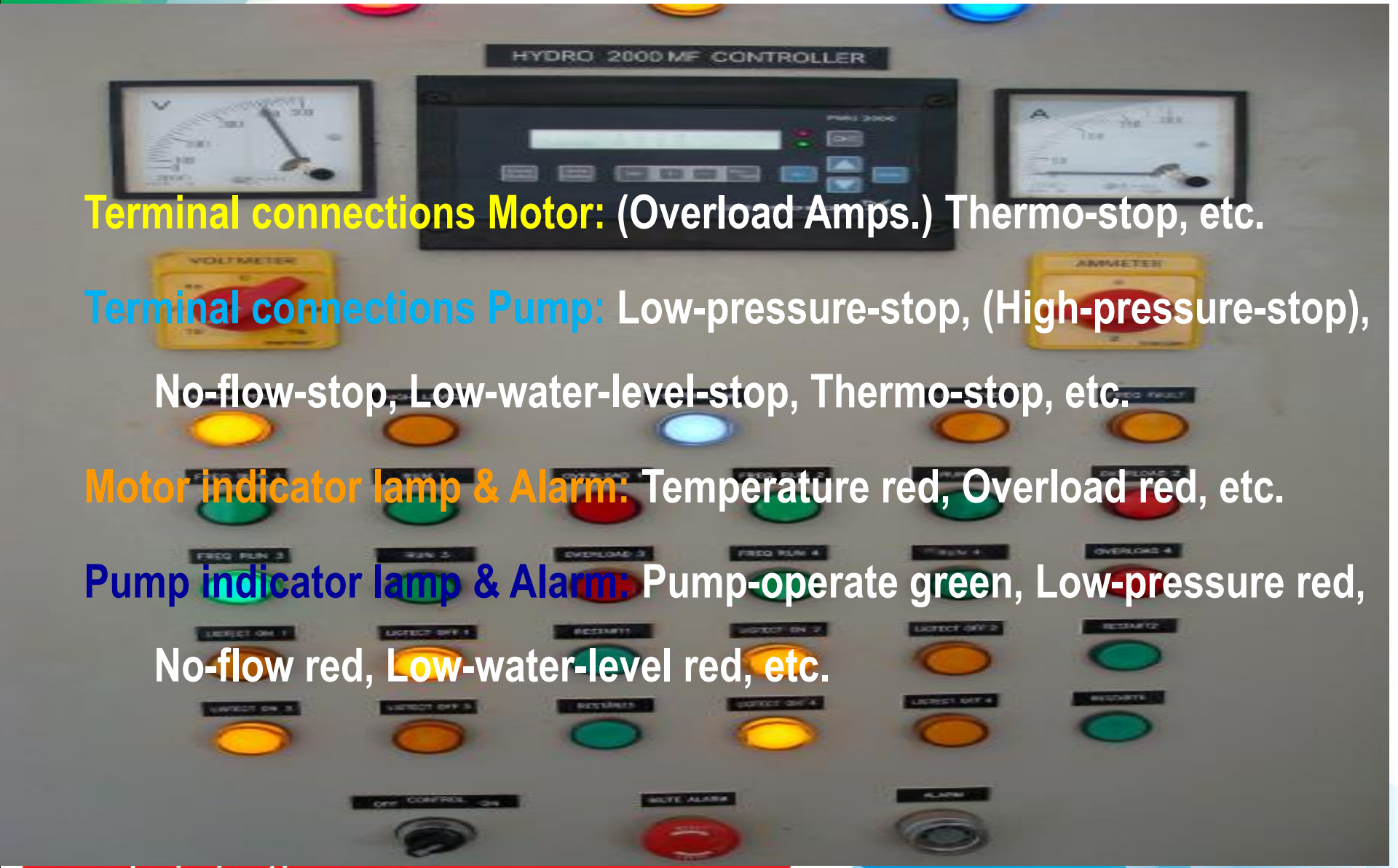
Main-switch, Push batten start, Ampere-meter, Volt-meter

Three phase selector switch, counter-hours-operation

Start up and Shut off clock, lighting inside the panel

Lighting for pump house, 220 volt sockets, No Volt-Relay

Auto/manual heater switch



Terminal connections Motor: (Overload Amps.) Thermo-stop, etc.

Terminal connections Pump: Low-pressure-stop, (High-pressure-stop), No-flow-stop, Low-water-level-stop, Thermo-stop, etc.

Motor indicator lamp & Alarm: Temperature red, Overload red, etc.

Pump indicator lamp & Alarm: Pump-operate green, Low-pressure red, No-flow red, Low-water-level red, etc.

11. Selecting Transformer criteria:

Voltage operation: 220V~, 380V~ etc.

a. Motor power: KW
b. Frequency operation: 50Hz or 60Hz
c. Current required (max.): Ampere
d. Transformer capacity: KVA
e. Transformer location: Up to 50m from electric-pump panel
f. Transformer coast
g. Electric cable/poles coast:

- from municipality to transformer
- From transformer to electric panel

9a. Selecting an engine criteria: Diesel energy operation

a. The required Power: HP (KW)
b. Efficiency: xx%
c. Voltage operation: 12V or 24V DC
d. Diesel Engine-Revolution: 1200-1800 RPM
e. Gas station distance: To engine fuel tank
f. Energy coast: US$ liter (diesel-fuel)
g. Fuel transportation coast: US$
h. Weather conditions: Temp, moisture etc.

10a. Selecting a diesel control panel criteria:

a. Voltage operation: 24V DC or 12V DC
b. The required revolution: RPM
c. Types of starting: Auto-soft-start, manually, etc.

Compulsory components

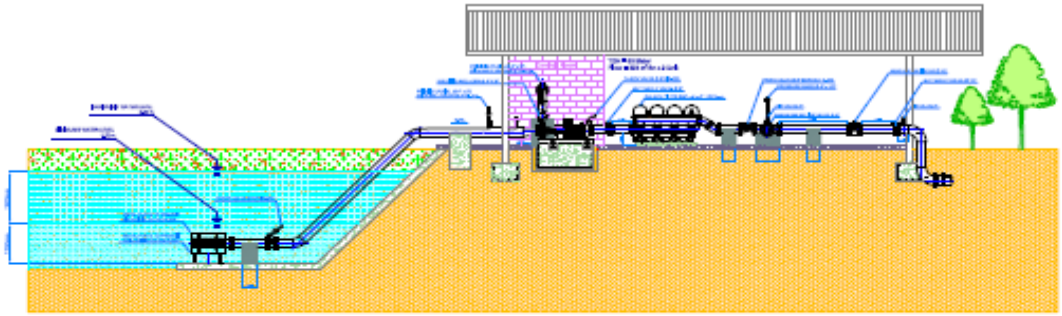
Key-switch, Tachometer, Thermometer-gage, battery-Volt-gage, oil-pressure-gage, counter-hours operation, start up and shut off clock, etc.

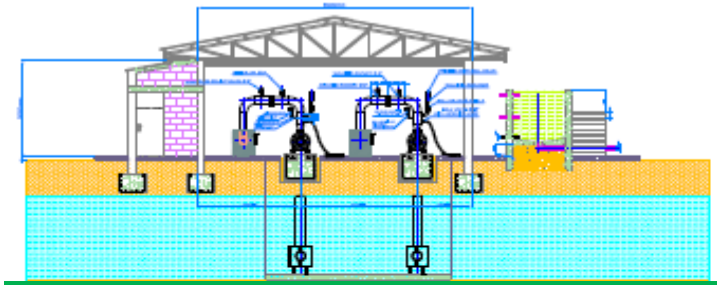
Terminal connections Engine: Oil-pressure-stop, Temperature-stop, Water-level-stop.

Terminal connections Pump: Low-pressure-stop, (High-pressure-stop), No-flow-stop, Low-water-level-stop, thermo=stop, etc.

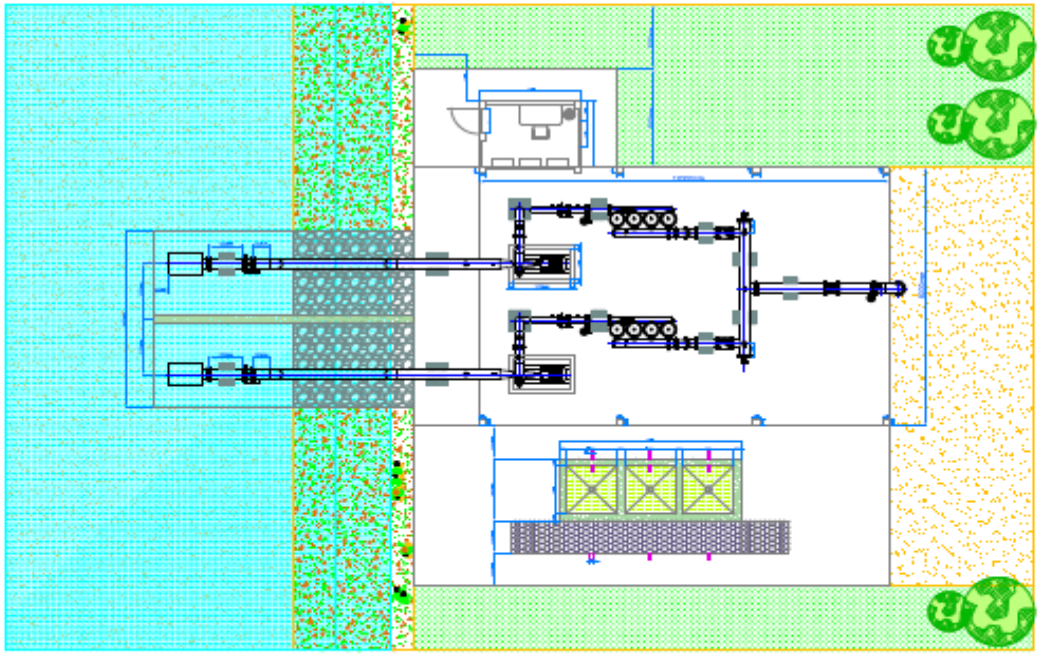
Engine indicator lamp: Oil-pressure red, Temperature red, Low-water-level red, etc.

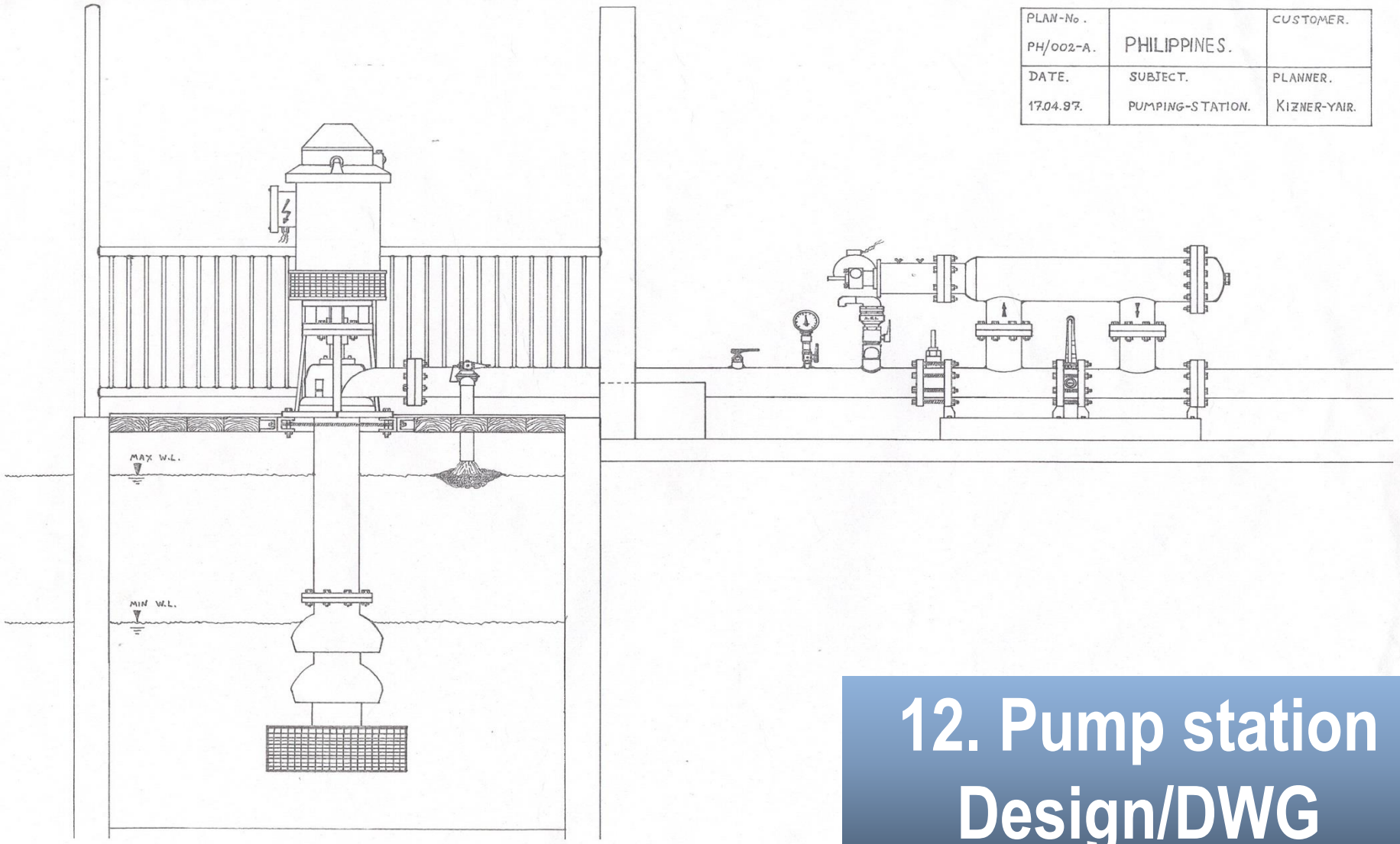
Pump indicator lamp: Pump-operate green, Low-pressure red, No-flow red, Low-water-level red, etc.





12. Pump station design/DWG





12. Pump station Design/DWG

- 13. B.O.M list
- 14. Preparation for constructing:
- leveling, civil work, welding, electrician, etc.
- 15. Construct the pump station.
- 16. Commissioning and training (Pump station manual operation)

Pump's Market

Pump – A mechanical device that convert mechanical forms of energy into hydraulic energy forms

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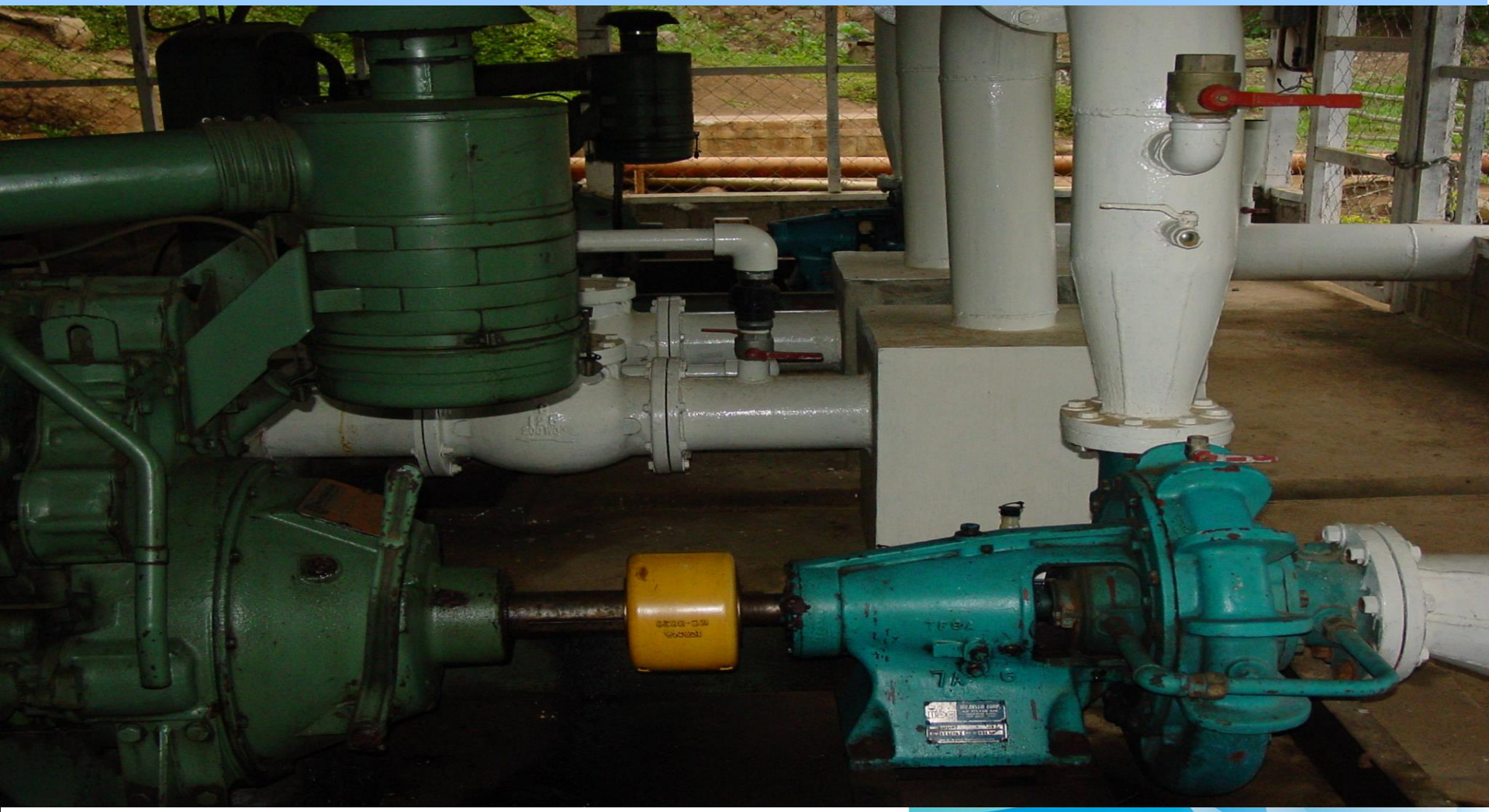
Single stage (One impeller)

Centrifugal pump

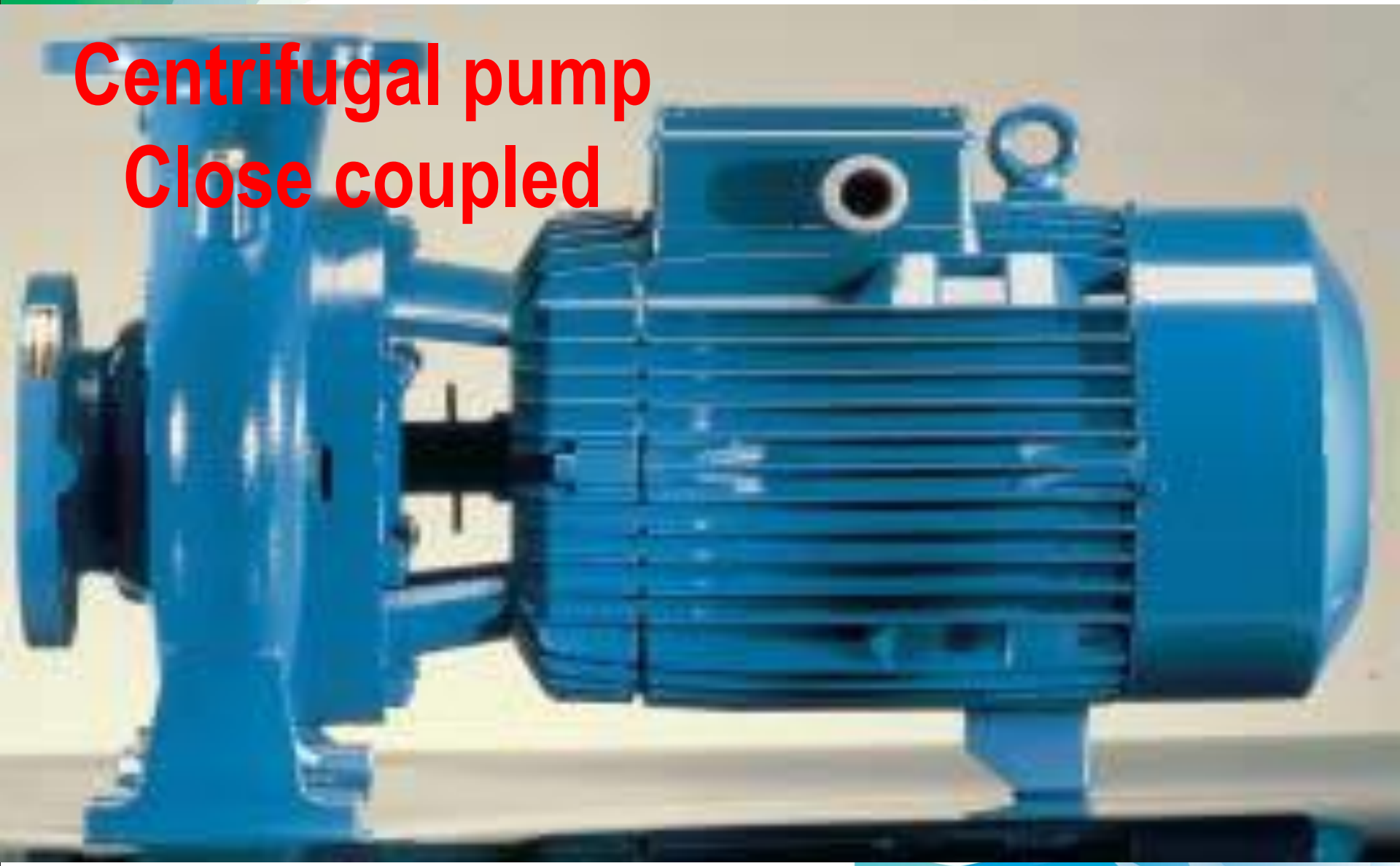


Centrifugal pump
Mono-block

Centrifugal pump

Centrifugal pump

Centrifugal pump
Close coupled



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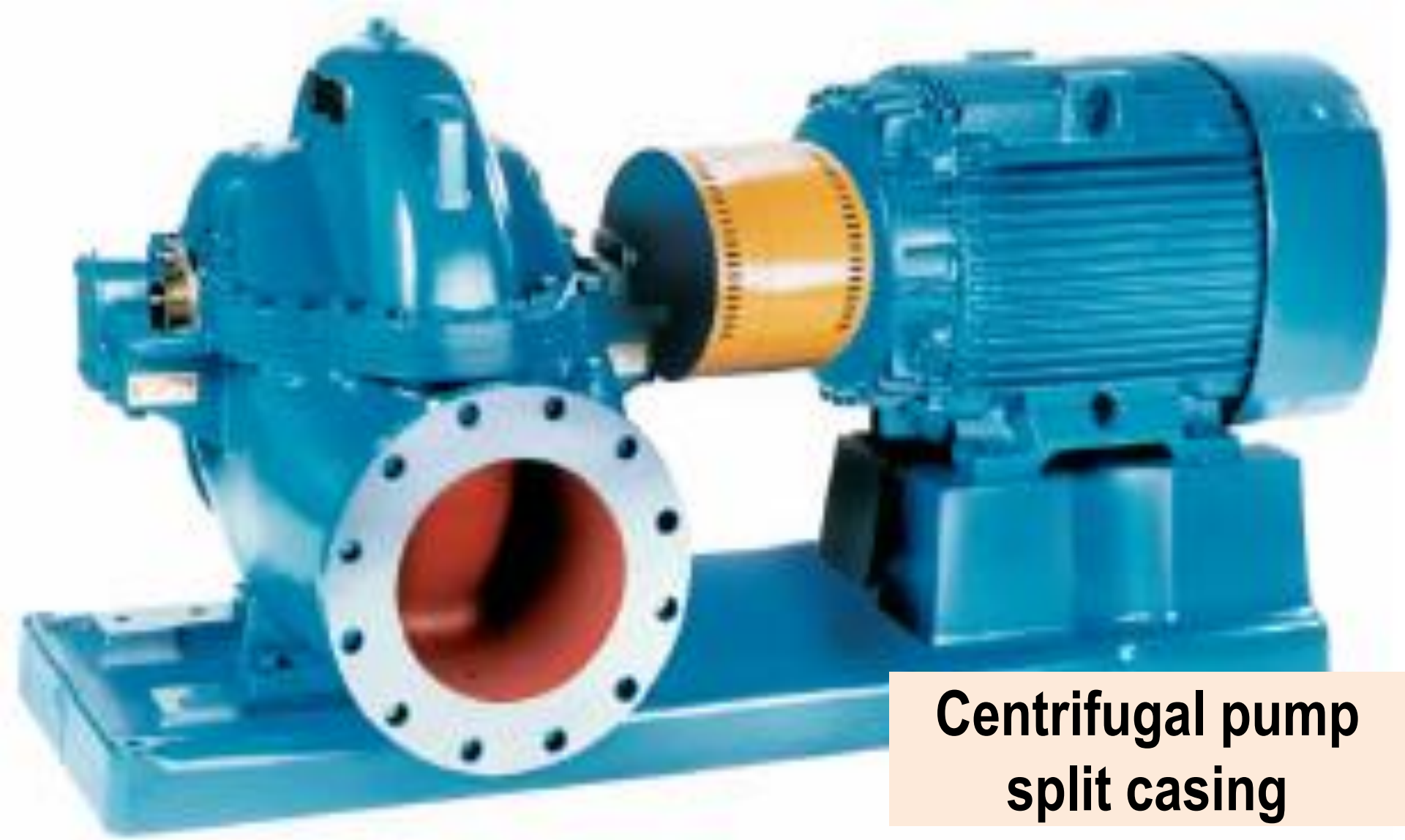

Centrifugal pump split casing

Inside Pump

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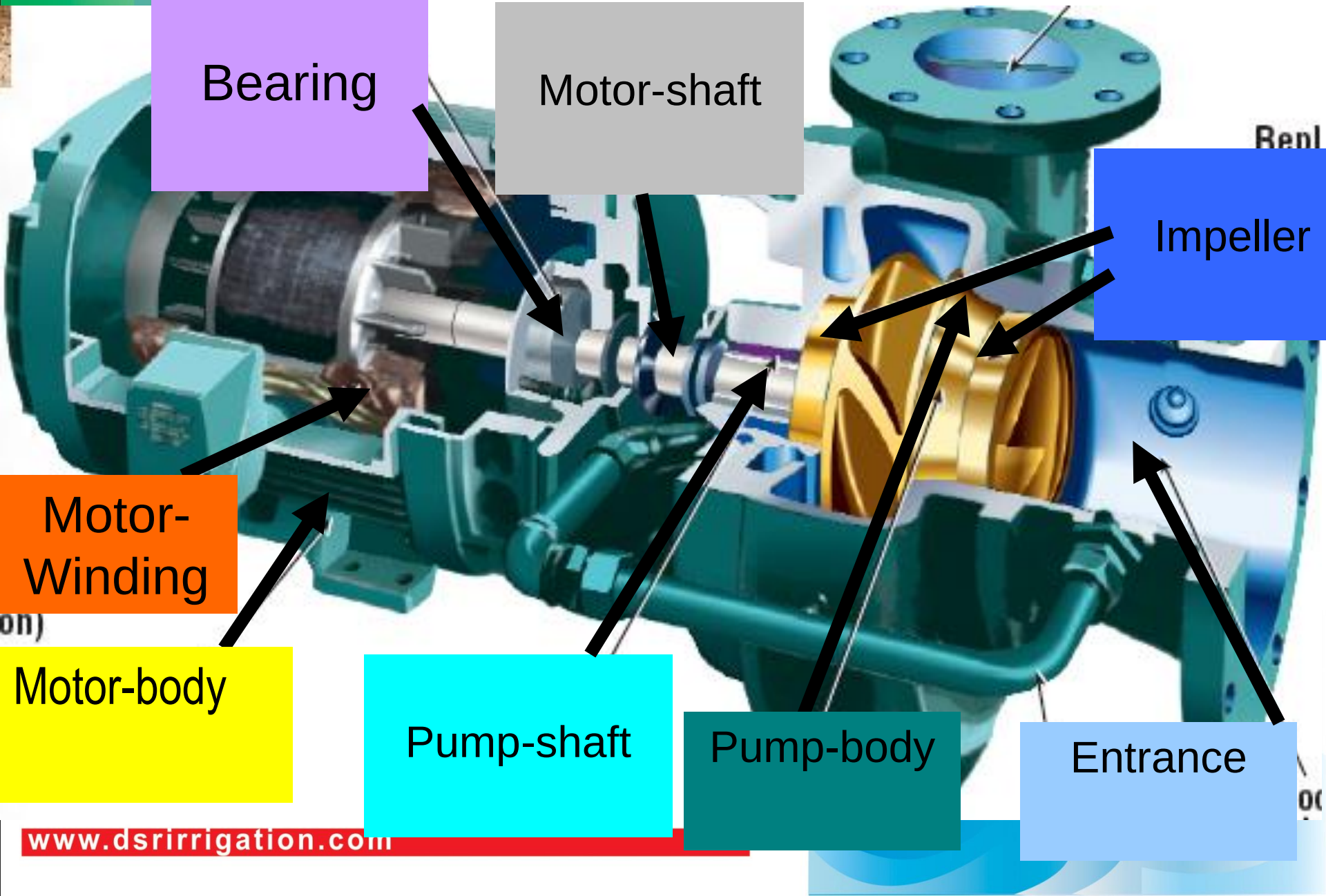


Horizontal centrifugal pump

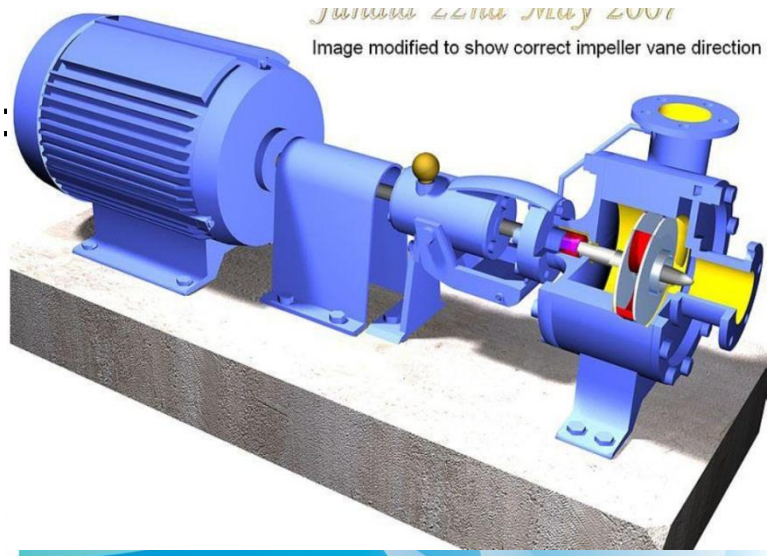
Use at: reservoirs, streams, shallow wells, booster pumps in irrigation pipelines.

All centrifugal pumps require priming before operation.

The suction line must be full with water and free of air and dirt.

Manual priming or gravity tank construct beside the pump station.

Centrifugal pump designed for either horizontal or vertical operation.



These pump most common in irrigation system, advantage:

Economic cost

Require less maintenance

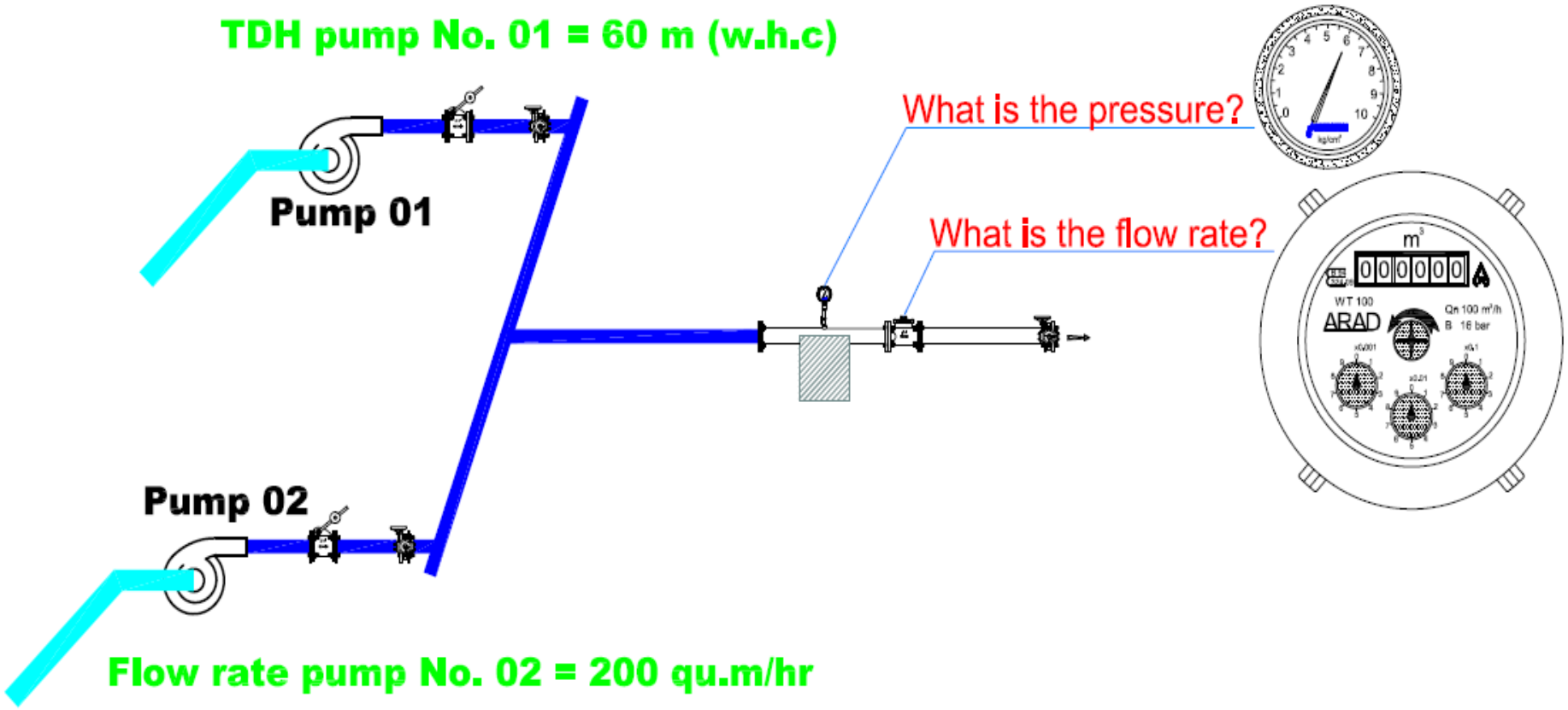
Easier to install

Accessible for inspection and maintenance

Centrifugal pump parallel connection

Flow rate pump No. 01 = 200 qu.m/hr

TDH pump No. 01 = 60 m (w.h.c)



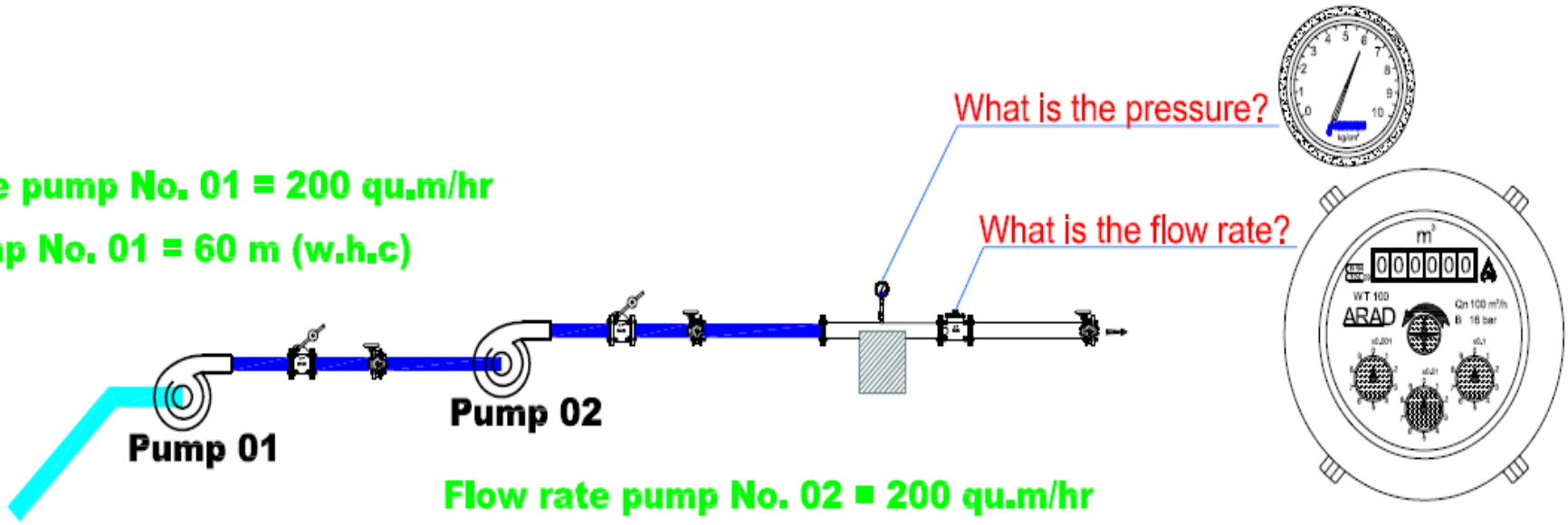
Flow rate pump No. 02 = 200 qu.m/hr

TDH pump No. 02 = 60 m (w.h.c)

Centrifugal pump tandem connection

Flow rate pump No. 01 = 200 qu.m/hr

TDH pump No. 01 = 60 m (w.h.c)

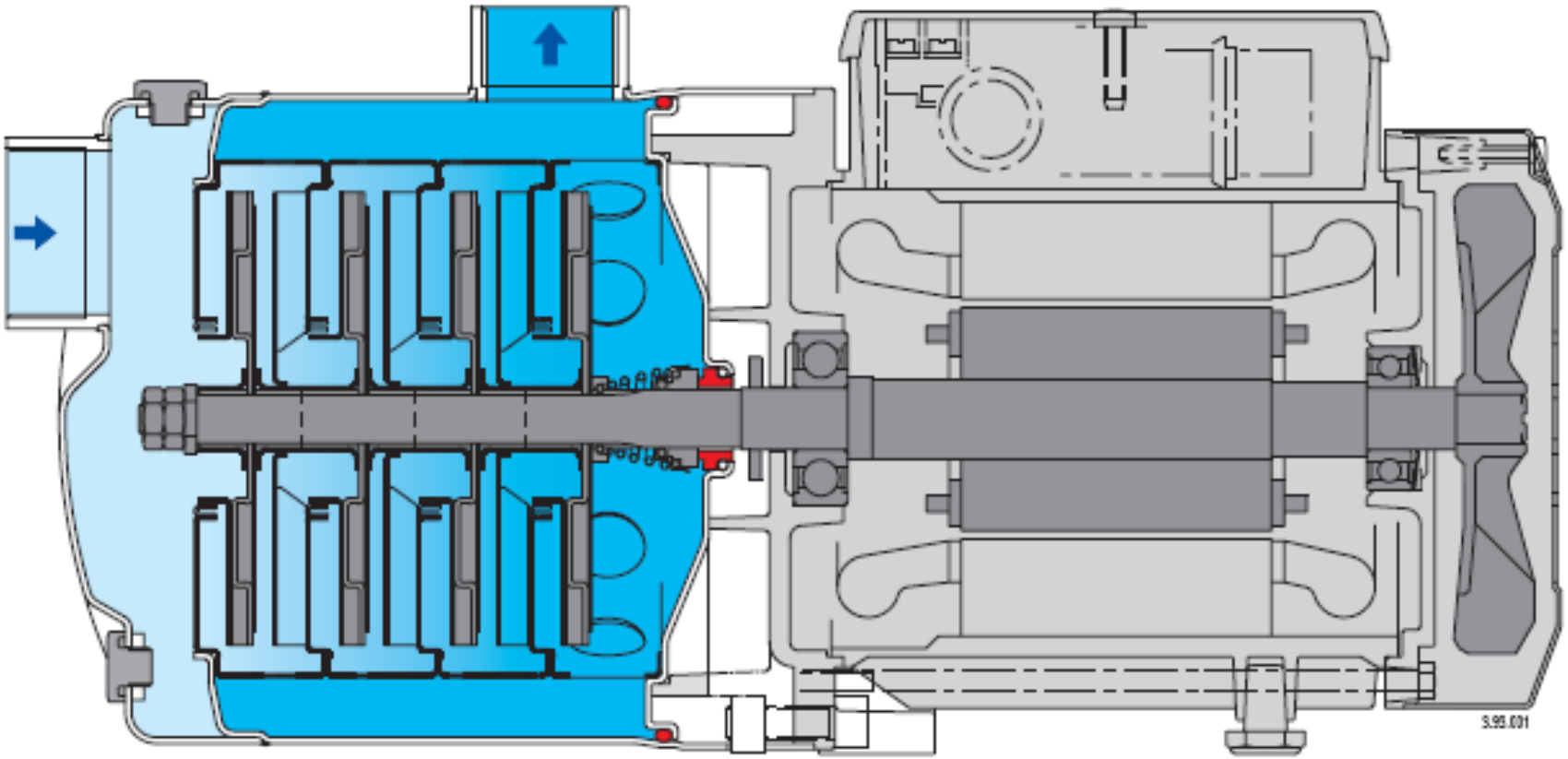


Flow rate pump No. 02 = 200 qu.m/hr

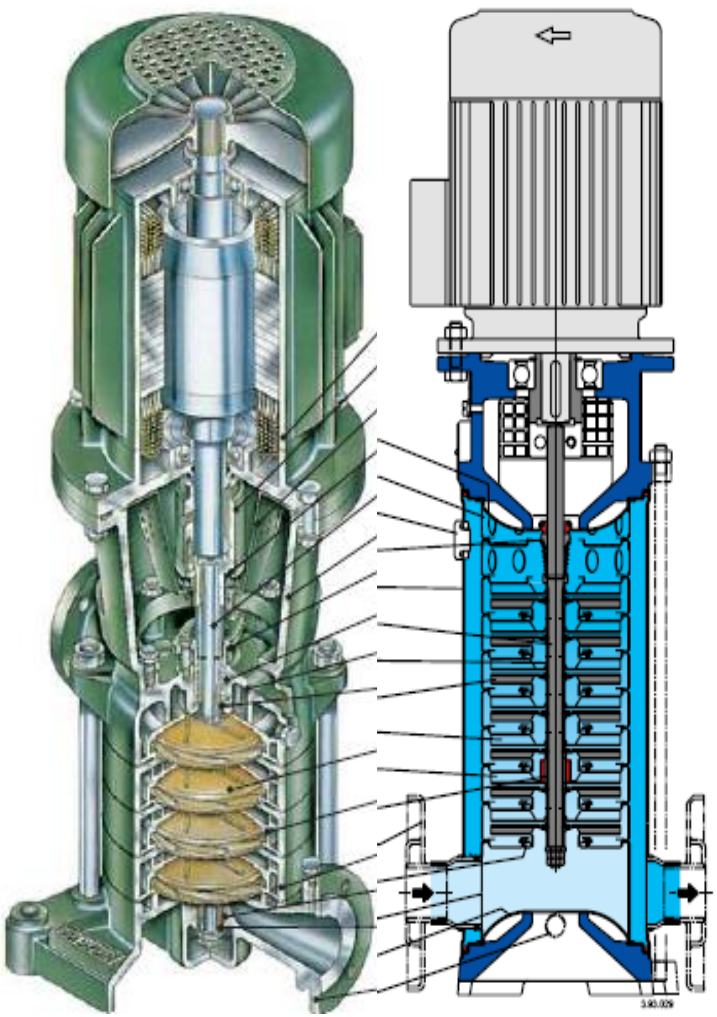
TDH pump No. 02 = 60 m (w.h.c)

Multistage
(Several impeller)

Horizontal centrifugal pump multi-stage



Vertical centrifugal pump multi-stage

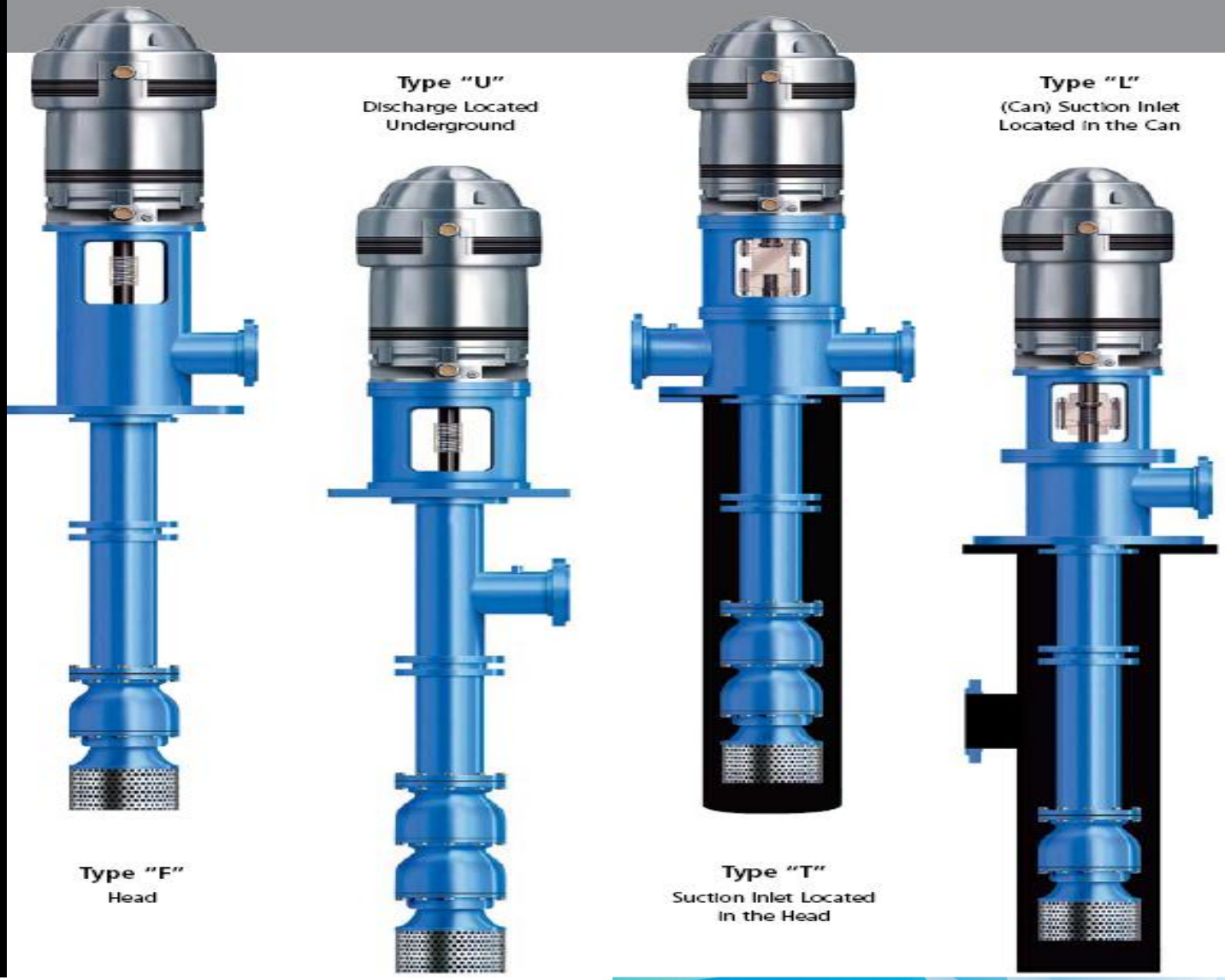


Turbine pump

suspended/soak in the water

Single & Multi stages

Turbine Pump (Vertical)



Turbine pump with diesel engine

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Turbine pump

Turbine pump

These pumps use where the water is below the limits of a centrifugal pump.
Turbine pump operate at surface water while bowls always under water.
No priming, efficient, expensive, and difficult to inspect/maintenance

The turbine pump has three main parts:
Head assembly: cast-iron
Shaft and column assembly
pump bowels assembly

The head foundation load take into account supported:
Column
shaft and bowels assembly
strainer
electric motor, right angle gear drive or belt drive
water discharge

Turbine pump cross section

The shaft and column assembly

provides a connection between the head and pump bowls.

The shaft transfer motor power to the impellers,

the column carries the water to the surface.

The turbine line shaft lubricate by oil or water.

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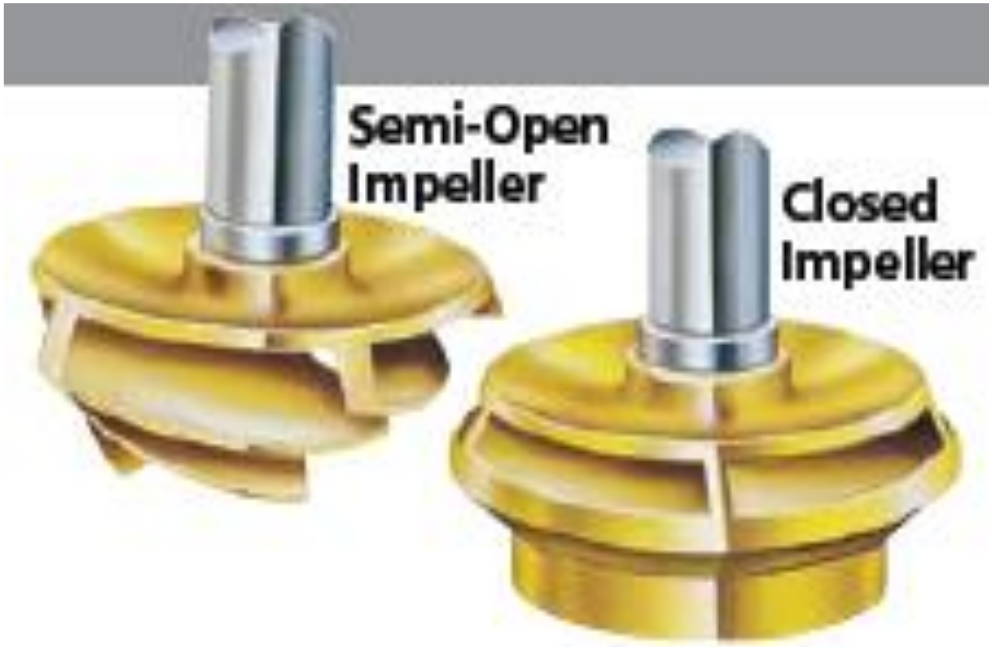
Intermediate bowls and impellers



Submersible pump

Turbine pump integral to submersible electric motor.

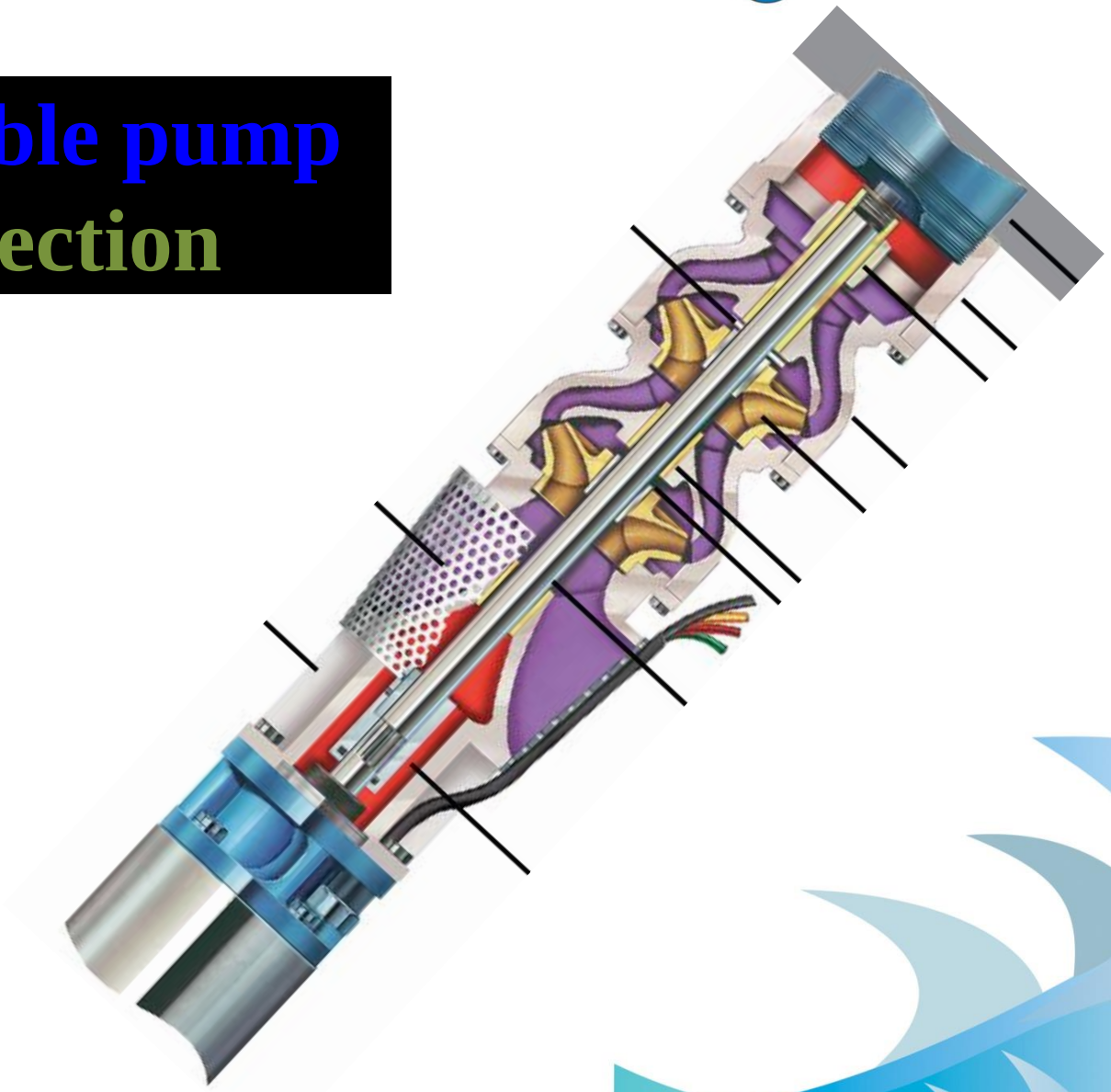
Pump and motor suspended/soak in the water.

Pump mounted above the motor

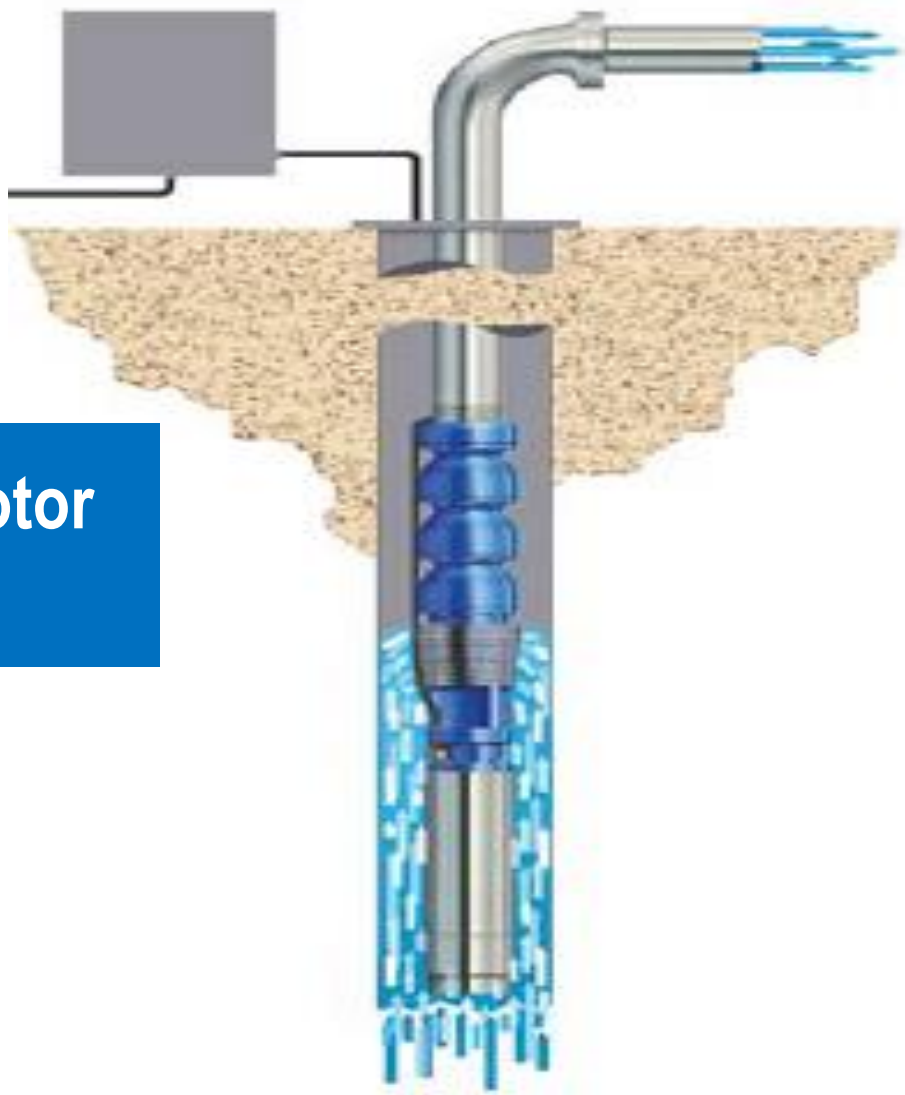
Water enters through screen located between the pump and motor.

Submersible motors are smaller in diameter and much longer than ordinary motors, lower efficiency.

Submersible pump cross section



Cooling motor process



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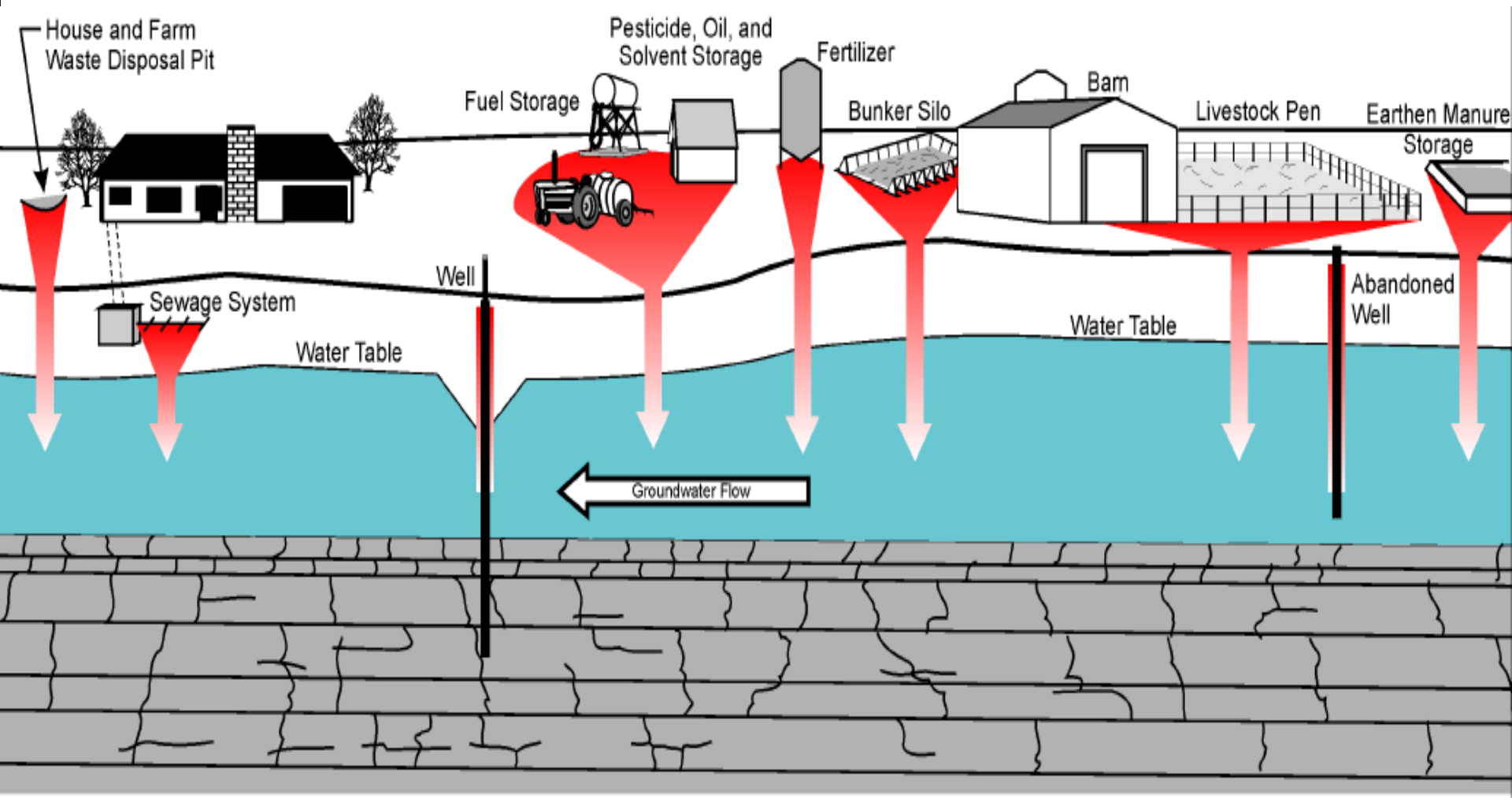
Submersible motor

Motors referred to dry or wet, the dry motor hermetically sealed with high dielectric oil to exclude water from the motor.
Wet motor open to the well water, the rotor and bearings actually operating in the water.
Submersible motors are smaller in diameter and much longer than ordinary motors lower efficiency.

Potential countryside contamination sources



Submersible pump

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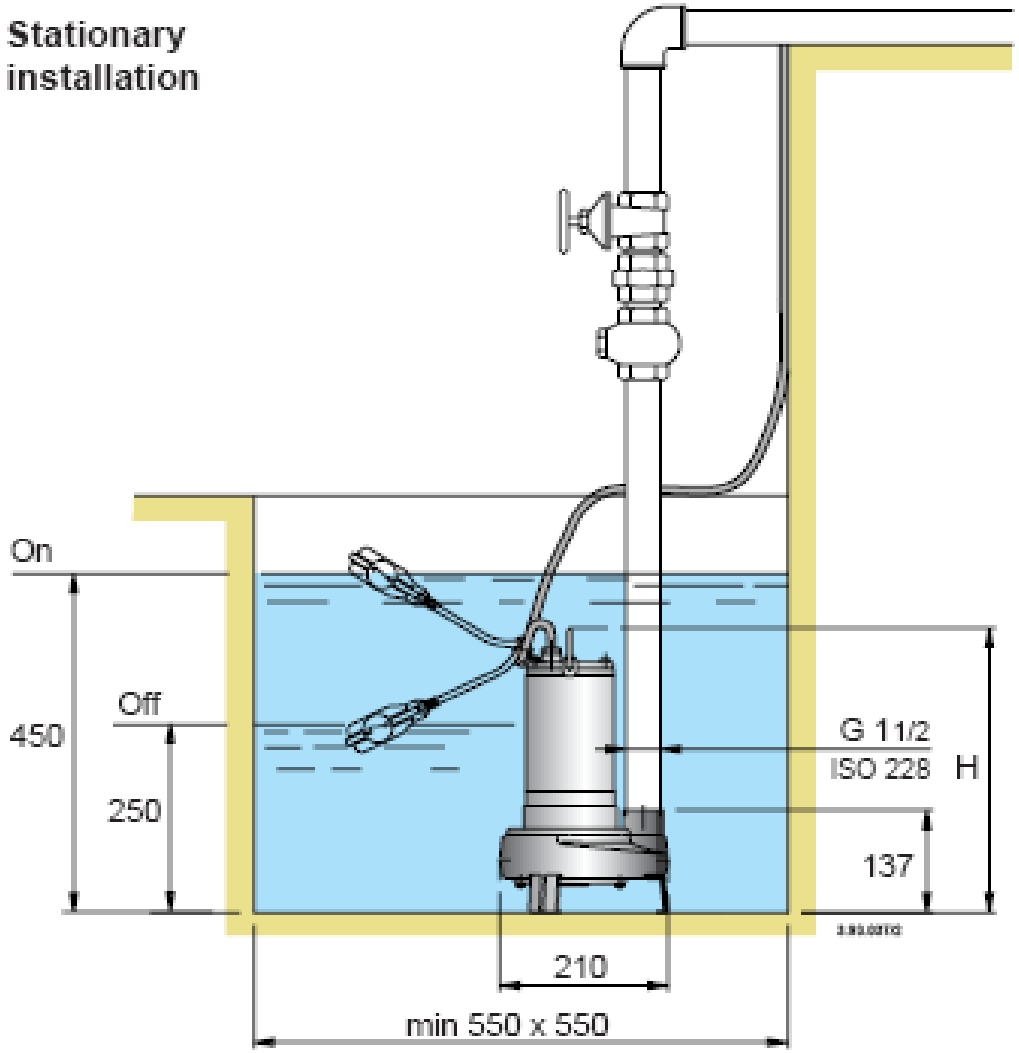
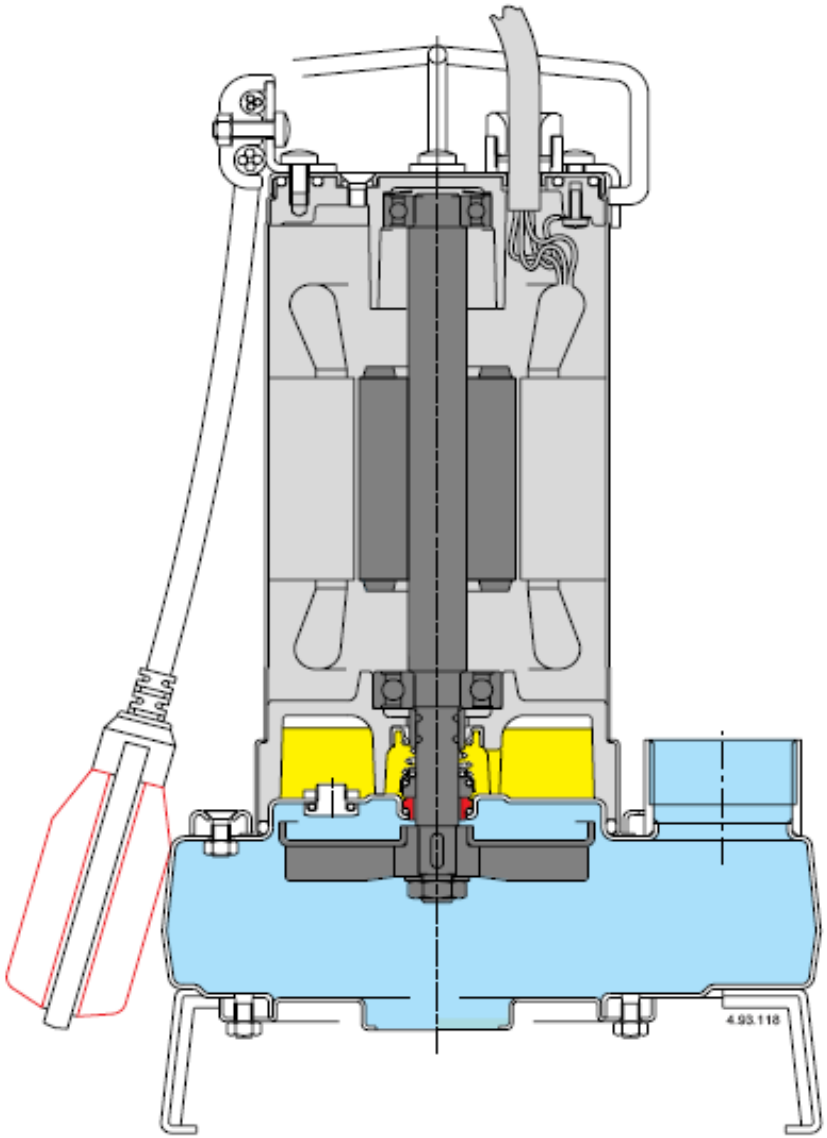




Pressure Head:

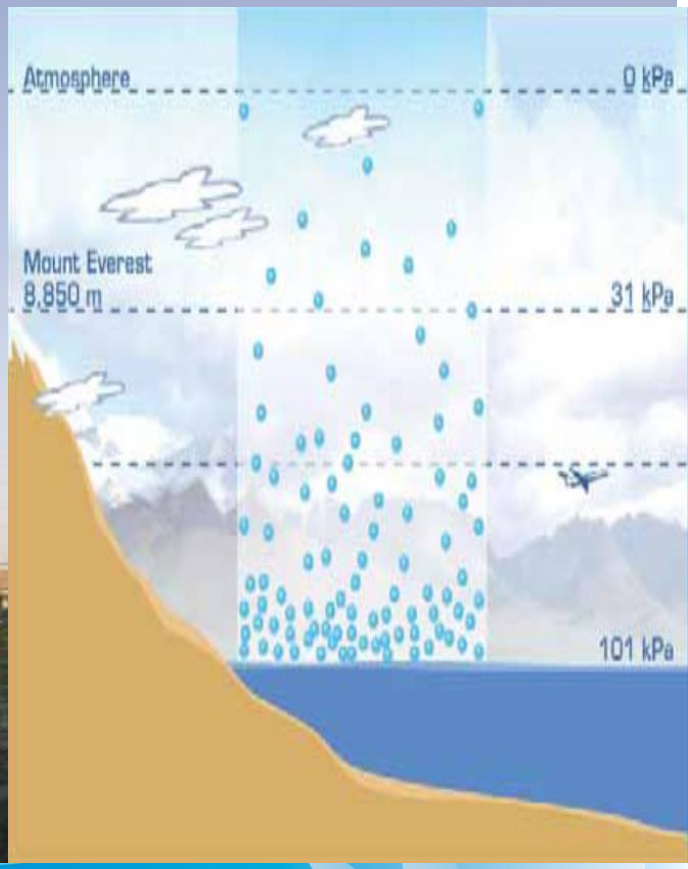
All the irrigation methods:

Drip, micro-sprinkler, midi-sprinkler, sprinkler, low-pressure fogger,

Gun-sprinkler, boom-sprayer, center pivot, etc., require a certain pressure to operate.

Most of the city-water-systems operate at:

3.5 bar (350KPa)



Suction Head

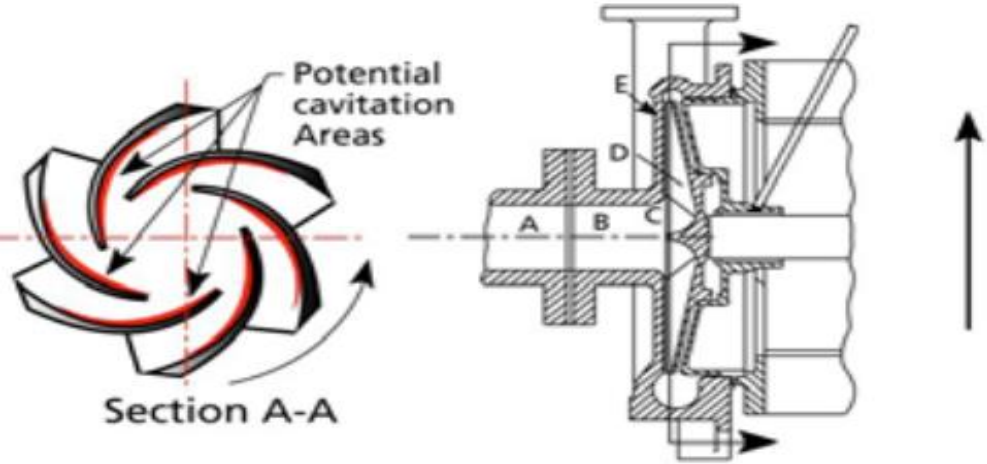
Theoretically the max. vertical suction by pump (lifting water) is equivalent to the barometric pressure 760mm (Hg) at sea level, 10.2m (w.h.c)

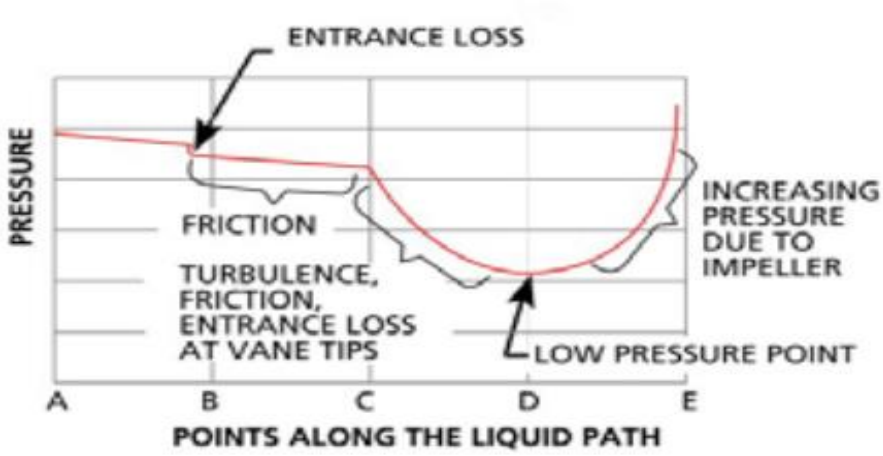
Manufactures determine the NPSH curve for their Pumps by laboratory tests.

The NPSH curve will increase when flow rate through the pump increase.

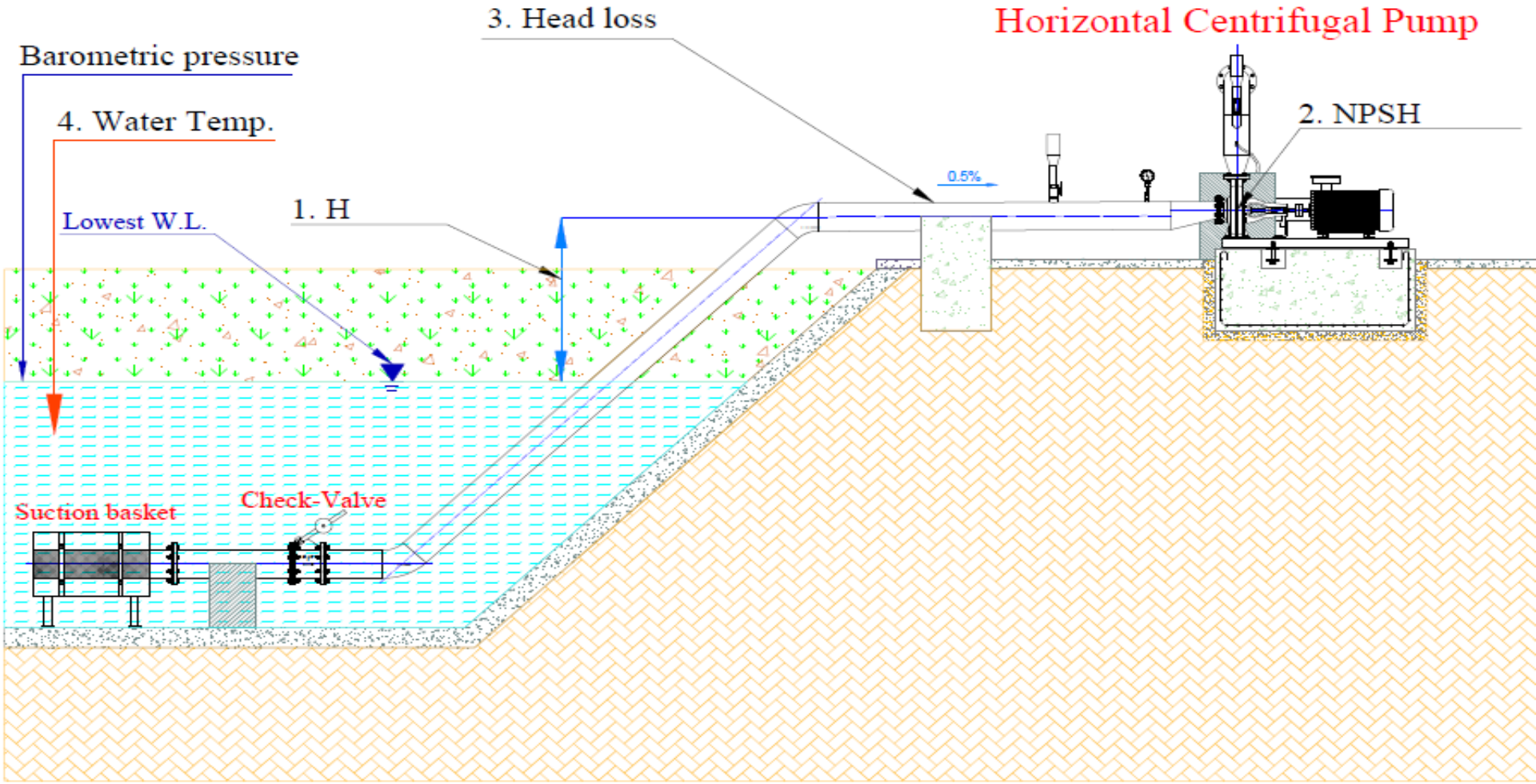
The Vertical suction lift value (m) reduced by the following factors:

1. NPSH: m.
2. Head-loss via the suction-system (pipe, arch, foot-valves, etc.): m.
3. Vapor pressure of the liquid at specified temperature: m.
4. Safety factor: m.





Suction Head



Vapor pressure of liquid at specific temperature

- 7Cº = 0.1m vP
- 18Cº = 0.2m vP
- 24Cº = 0.3m vP
- 28Cº = 0.4m vP
- 32Cº = 0.5m vP
- 36Cº = 0.6m vP
- 40Cº = 0.7m vP
- 42Cº = 0.8m vP
- 45Cº = 0.9m vP
- 48Cº = 1.0m vP
- 54Cº = 1.5m vP
- 60Cº = 2.0m vP
- 68Cº = 3.0m vP
- 75Cº = 4.0m vP
- 82Cº = 5.0m vP
- 88Cº = 6.0m vP
- 99Cº = 10.0m vP

Max. vertical suction pump will lifted

An example:

Pump NPSH: 4.0m

Suction system (pipe and acc.) head loss: 1.0m

Vapor pressure: 0.3m @ 25C°

Safety factor: 1.0m

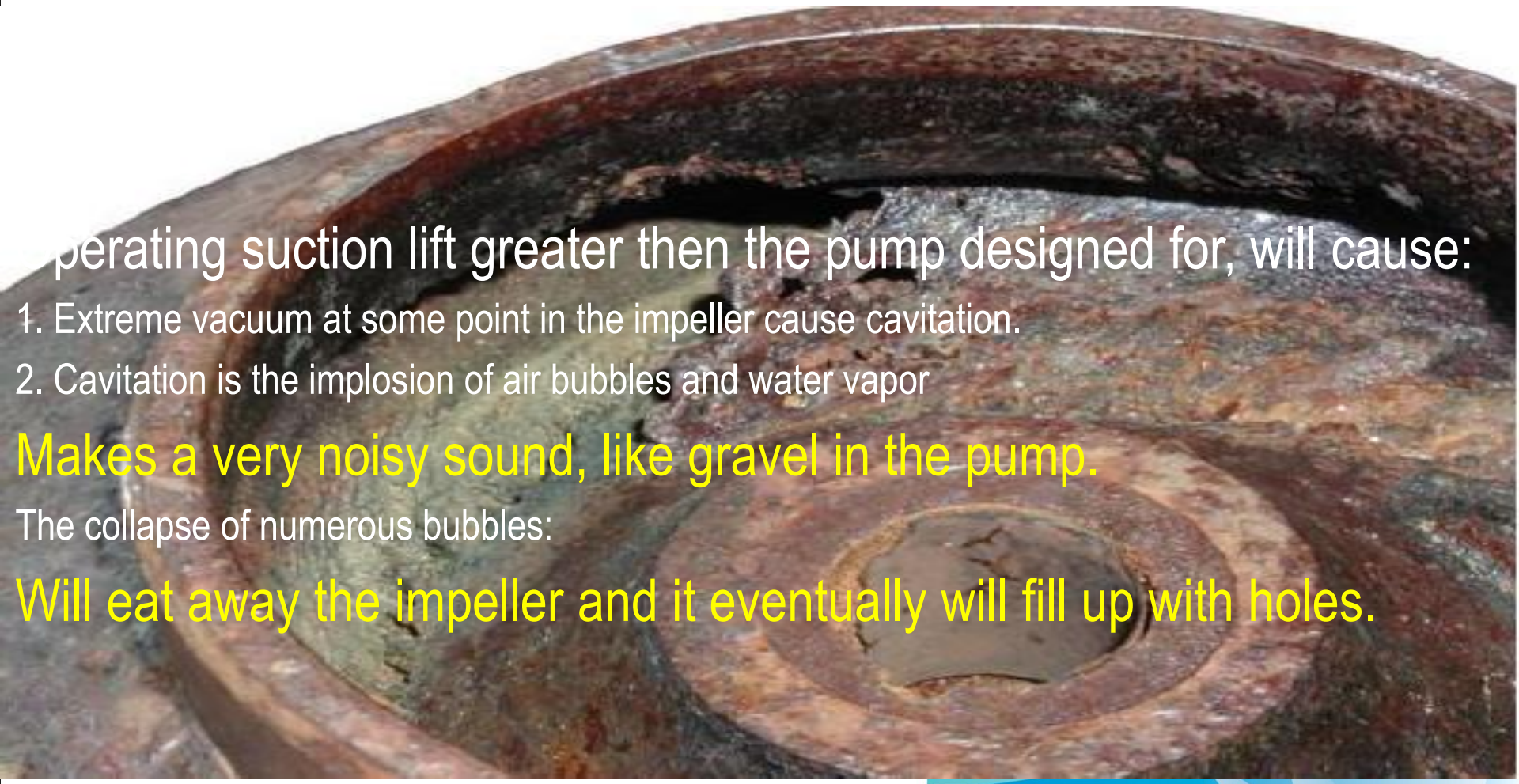
Max. vertical lifting water: H - (NPSH + H.L. + Vapors + S.f.) = Max. lifting

- Max. vertical lifting water: 10.2 - (4.0+1.0+0.3+1.0) = 3.9m

Suction system flow velocity (pipe and acc.): ~1.5m/sec.

Suction-pipe diameter, larger then the Delivery-pipe diameter.

Pump Suction system



perating suction lift greater then the pump designed for, will cause:

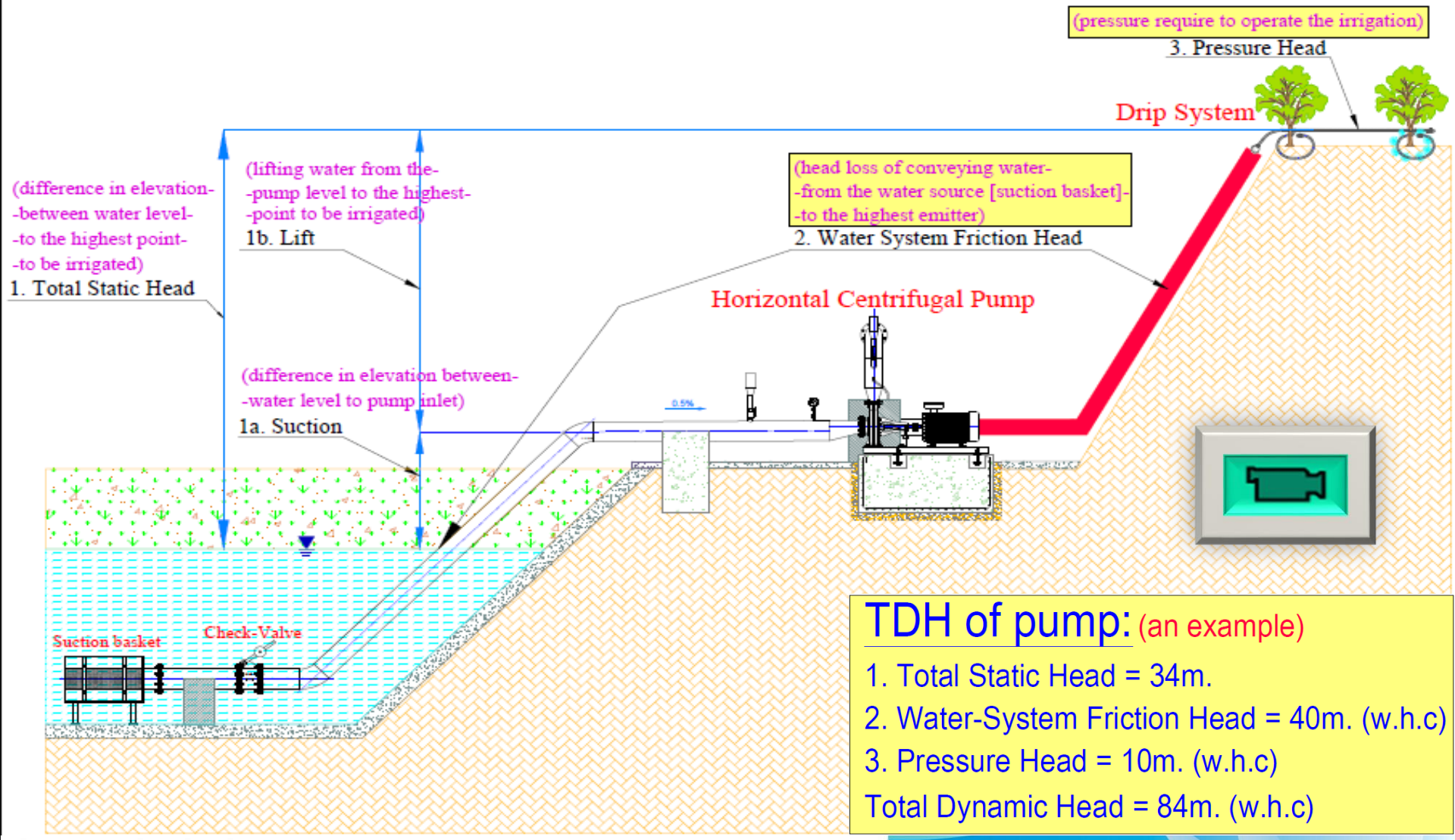
1. Extreme vacuum at some point in the impeller cause cavitation.
2. Cavitation is the implosion of air bubbles and water vapor

Makes a very noisy sound, like gravel in the pump.

The collapse of numerous bubbles:

Will eat away the impeller and it eventually will fill up with holes.

Total Dynamic Head (TDH)



TDH of pump: (an example)

1. Total Static Head = 34m.
2. Water-System Friction Head = 40m. (w.h.c)
3. Pressure Head = 10m. (w.h.c)

Total Dynamic Head = 84m. (w.h.c)

Total Static Head

The total vertical distance the pump required to lift the water-

-from the lowest water level to the highest point to be irrigated

(In deep-well from the dynamic water table)

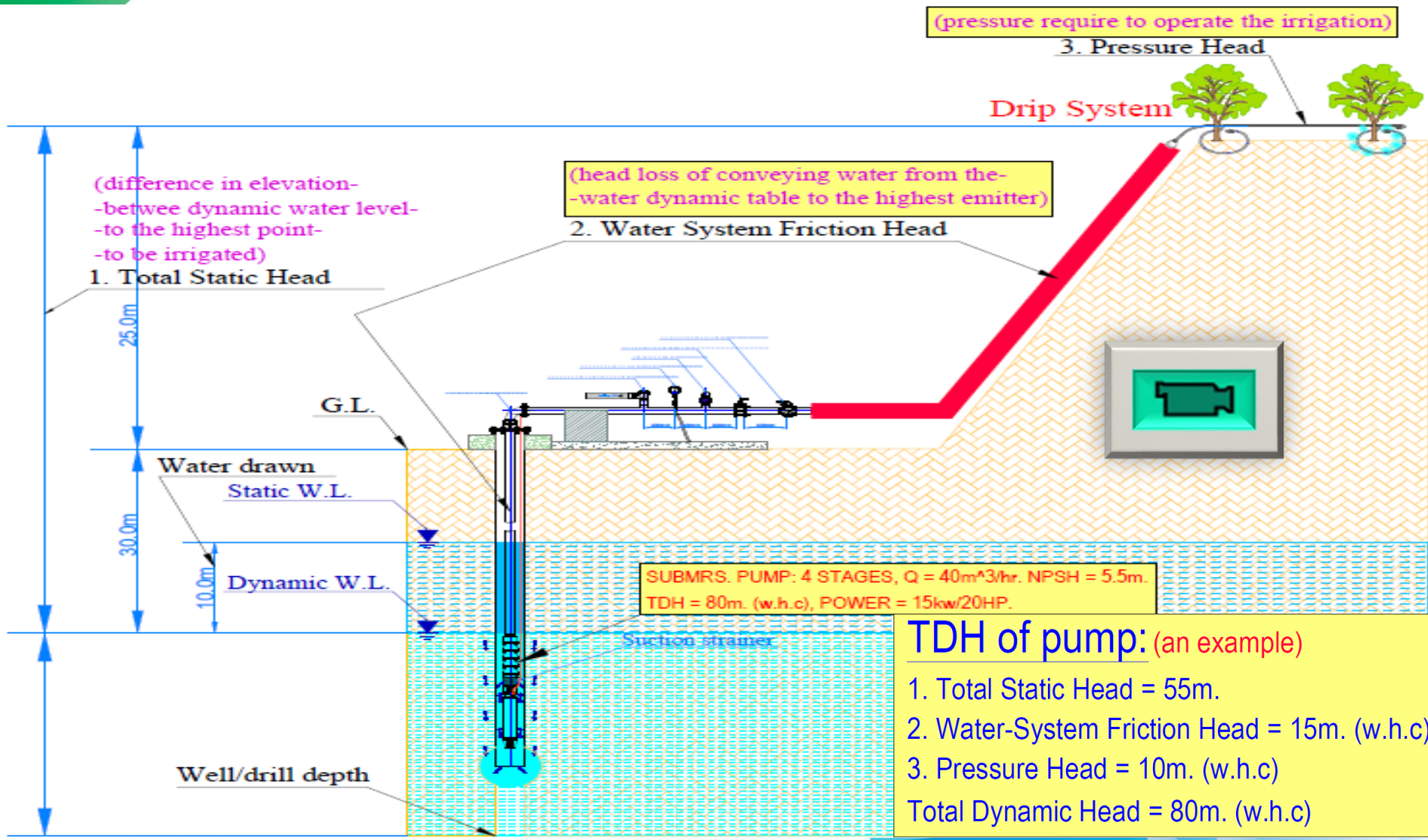
GH cooling system (CoolNet), please add. 4m to the calculation

Total Dynamic Head (TDH)

- 1. Total static head: Lowest water level to the highest point to be irrigated
- 2. Pressure head: Emitter operation pressure requirement
- 3. Friction head: Piping network and hydraulic devices (head loss)

The summary of them, crate the: Total Dynamic Head (TDH)

Total Dynamic Head (TDH)



TDH of pump: (an example)

1. Total Static Head = 55m.
2. Water-System Friction Head = 15m. (w.h.c)
3. Pressure Head = 10m. (w.h.c)

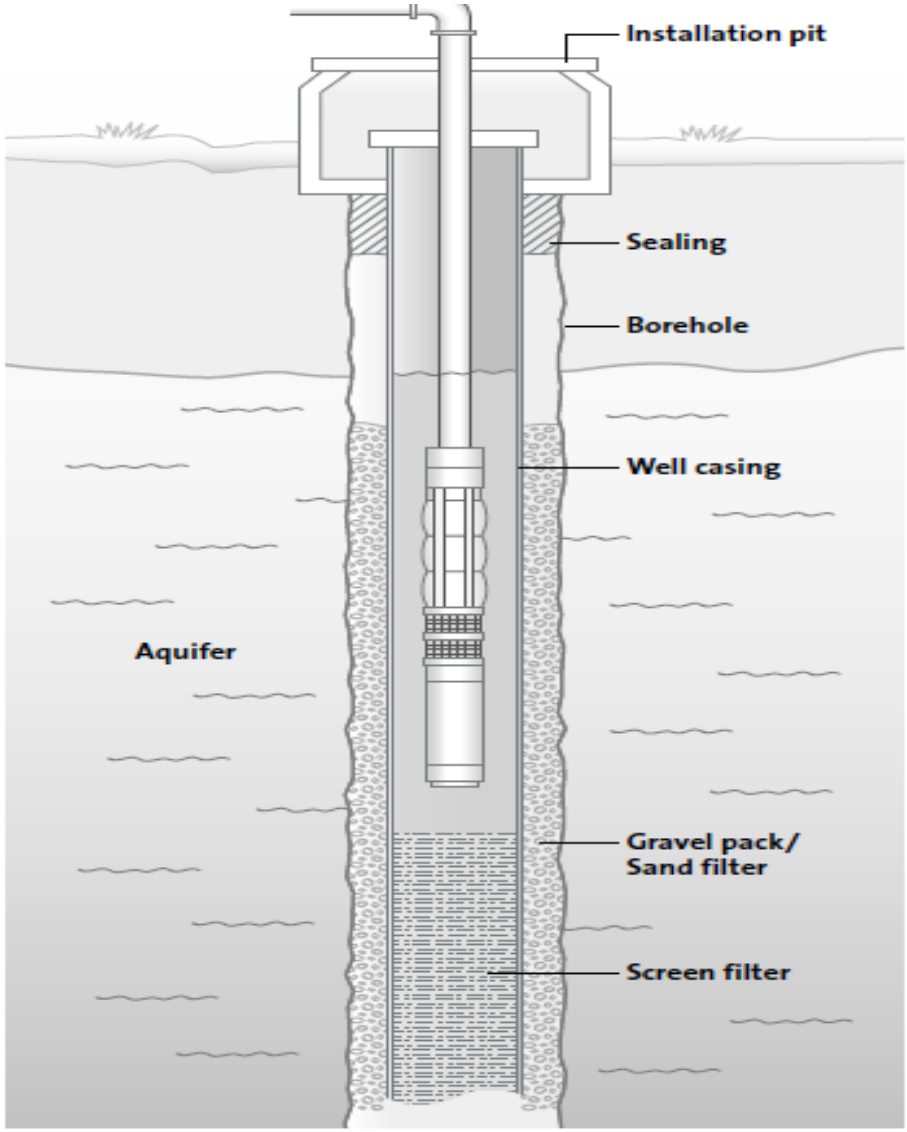
Total Dynamic Head = 80m. (w.h.c)

A well is a hole, stretching from the surface of the earth to the underground aquifer, where the ground-water is found. The depth of the well may vary from a few meters to several hundred meters.

Wells are typically drilled with special drilling equip-ment, which is able to pentrate the various layers of the ground, such as sand, clay, bedrock, etc. Inside the drilled hole a casing (pipe) is typically installed, which prevents the well from collapsing around the pump.

Below the casing, and in line with the aquifer, is an-other 'casing' with fine slots. This is the well screen, where the slots allows the water to enter the well. It holds back sand and larger particles trying to enter the well. See fig. 50.

To improve the filtering function, the borehole typi-cally features a diameter that is 2-3" larger than the casing. A fine sand gravel pack filter is placed be-tween the casing and the aquifer, as shown fig. 45. Some casings come with a pre-made gravel pack filter. Made correctly, this filtering method prevents sand and silt from entering the well.



Power Requirements:

The Power added, to Water as it moves through a pump

Calculated with the following formula:

Power calculation: kw

Data:
Q = Flow rate (m^3/hr.)
TDH = Total dynamic head (m) [w.h.c]
WkwP = Water Power (kw)

Formula:
Wkw = Q x TDH/360

The actual power required to run a pump will be higher then this because pumps and drives are not 100% efficient.

The power (kw) required at the pump shaft to pump a specified flow rate against a specified TDH
Is the Brake kw power (BkwP) which is calculated with the following formula:

Data:
Pump Eff. – Efficiency of the pump usually read from a pump curve by percentages convert to decimal fraction
Drive Eff. – Efficiency of the drive unit between the power source and the pump usually read from a drive curve by percentages convert to decimal from 0.00-1.00
BkwP – Break kw power (continuous kw power rating of the power unit).

Formula:
BkwP = WkwP/Pump Eff. x Drive Eff.
1KW = 1.3402HP

Power calculation: HP

Data:
Q = Flow rate (m3/hr.)
TDH = Total dynamic head (m) [w.h.c]
WHP = Water Horse Power

Formula:
WHP = Q x TDH/268.452 (270)

The actual power required to run a pump will be higher then this because pumps and drives are not 100% efficient.

The horsepower required at the pump shaft to pump a specified flow rate against a specified TDH
Is the Brake Horsepower (BHP) calculated with the following formula:

Data:
Pump Eff. – Efficiency of the pump usually read from a pump curve by percentages convert to decimal fraction
Drive Eff. – Efficiency of the drive unit between the power source and the pump usually read from a drive curve by percentages convert to decimal from 0.00-1.00
BHP – Break Horsepower (continuous horsepower rating of the power unit)

Formula:
BHP = WHP/Pump Eff. x Drive Eff.
1HP = 0.7457KW

Electric supply by generator set

Fuel consumption: 1liter of diesel per ~5KVA

Depend on generator efficiency

Effect of revolution changing on pump performance:

An example: RPM are increased by 1.5

Flow rate will increased by 1.5 times

TDH will increase by (1.5)^2 or 2.25 times

BHP will increase by (1.5)^3 or 3.375 times

Pump revolution (Speed):

Low revolution Pump: 1400 RPM to 1800 RPM
High revolution Pump: 2800 RPM to 3600 RPM

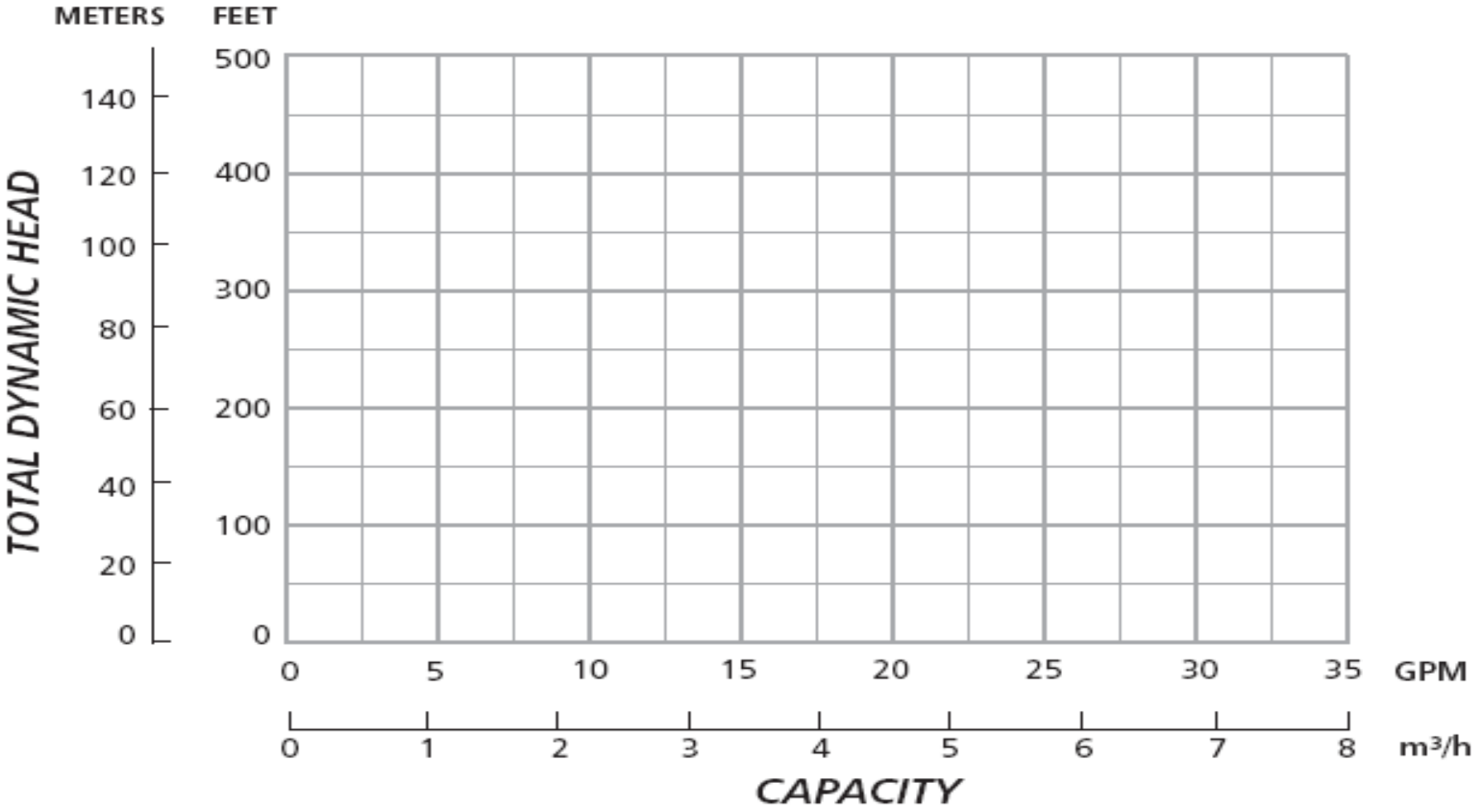
Electric motor fix revolution (50 Hz) 1450 RPM or 2900 RPM
Electric motor fix revolution (60 Hz (frequency) 1750 RPM or 3500 RPM

Electric motor can be variability speed with frequent-changer:
Revolution: 0-1450 RPM, 0-2900 RPM, 0-1750 RPM and 0-3500 RPM

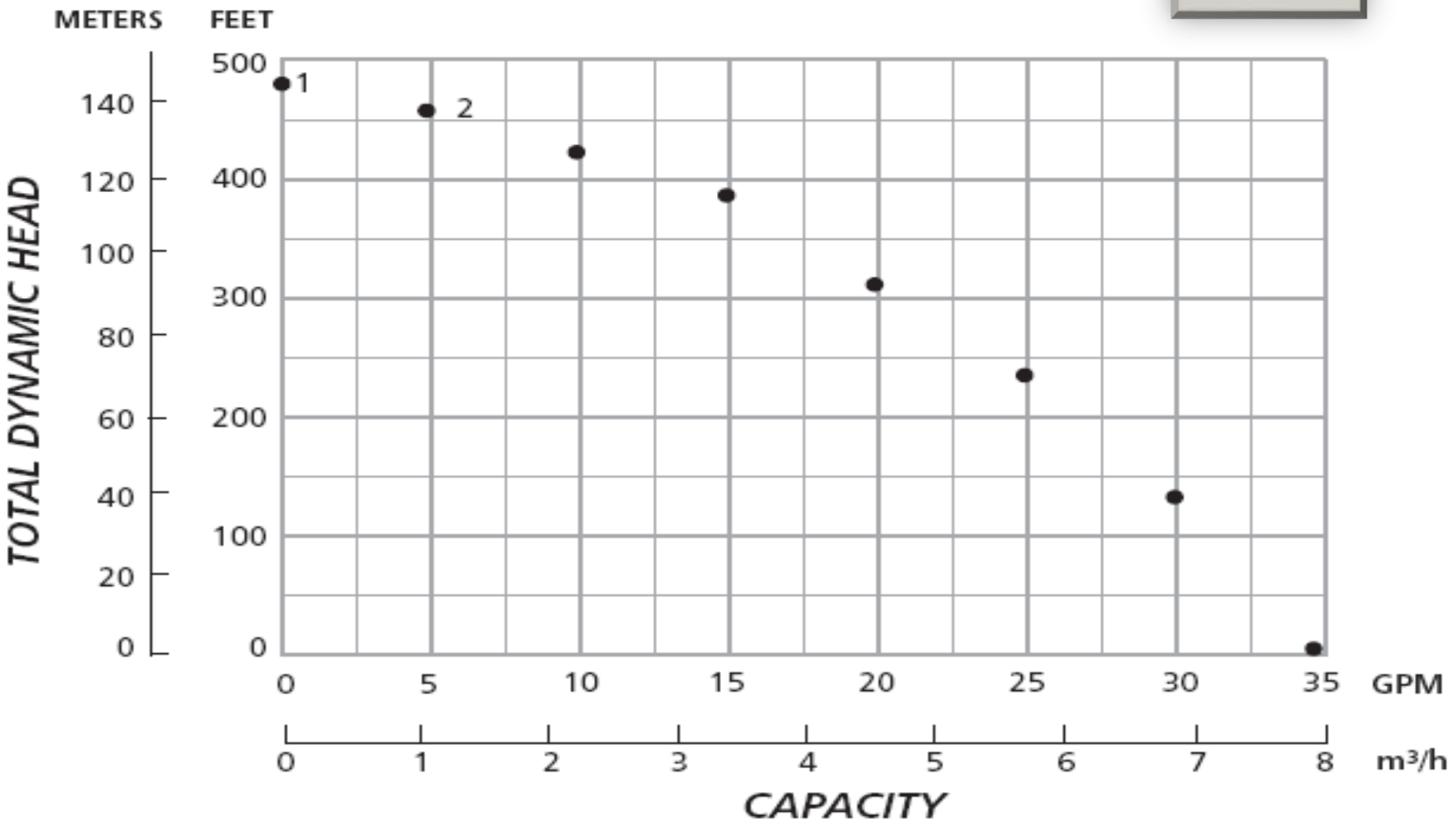
Pump operate by Diesel engine design for: 1400-1800 RPM
Truck Diesel engines operates at 1400-2500 RPM,
Truck Diesel engines tempt to merge low revolution pump to hybrid

Low efficiency, High energy spending

Reading a pump curve



Reading a pump curve



- Pump station installation component (not include electric panel)

1. Hydraulic and sensor (hydro-electric 
2. Pipes and fittings size (diameter)

Suction basket/strainer

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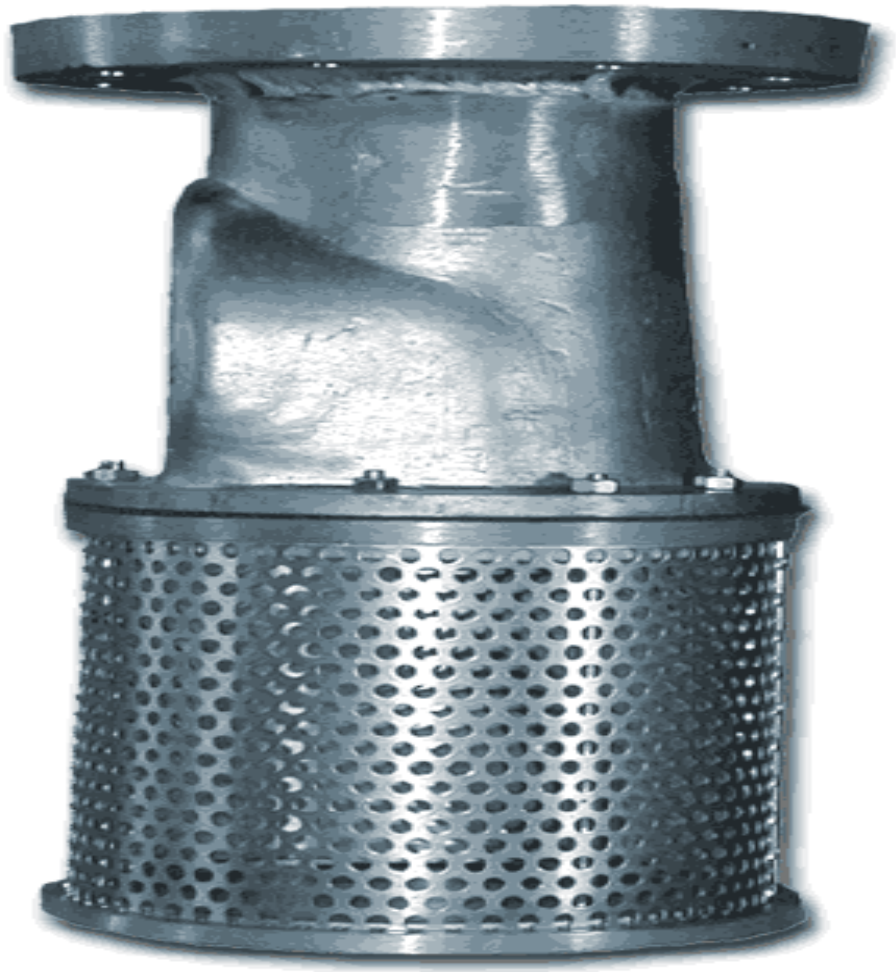
Foot-Valve



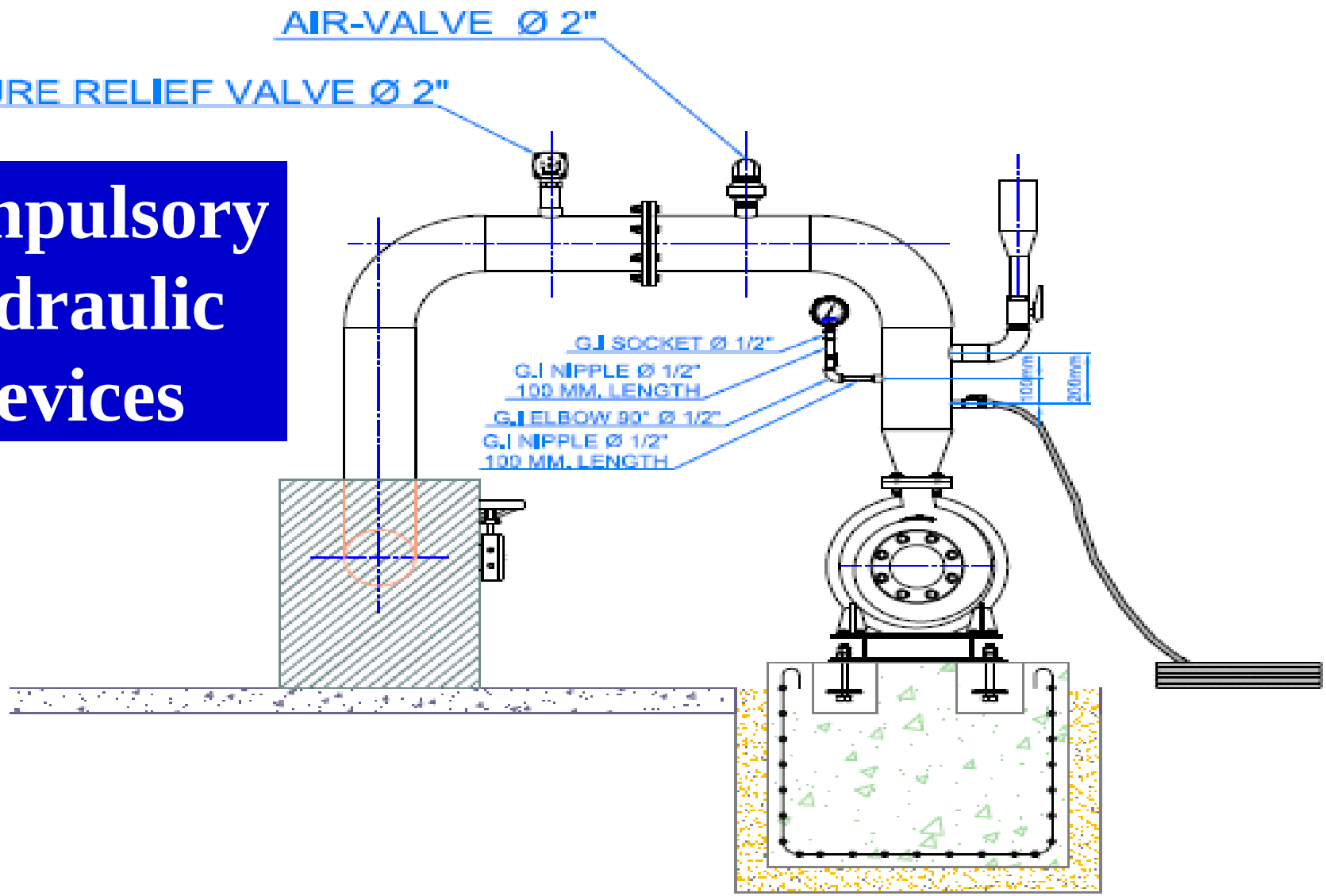
NR-020

Eccentric to pump inlet

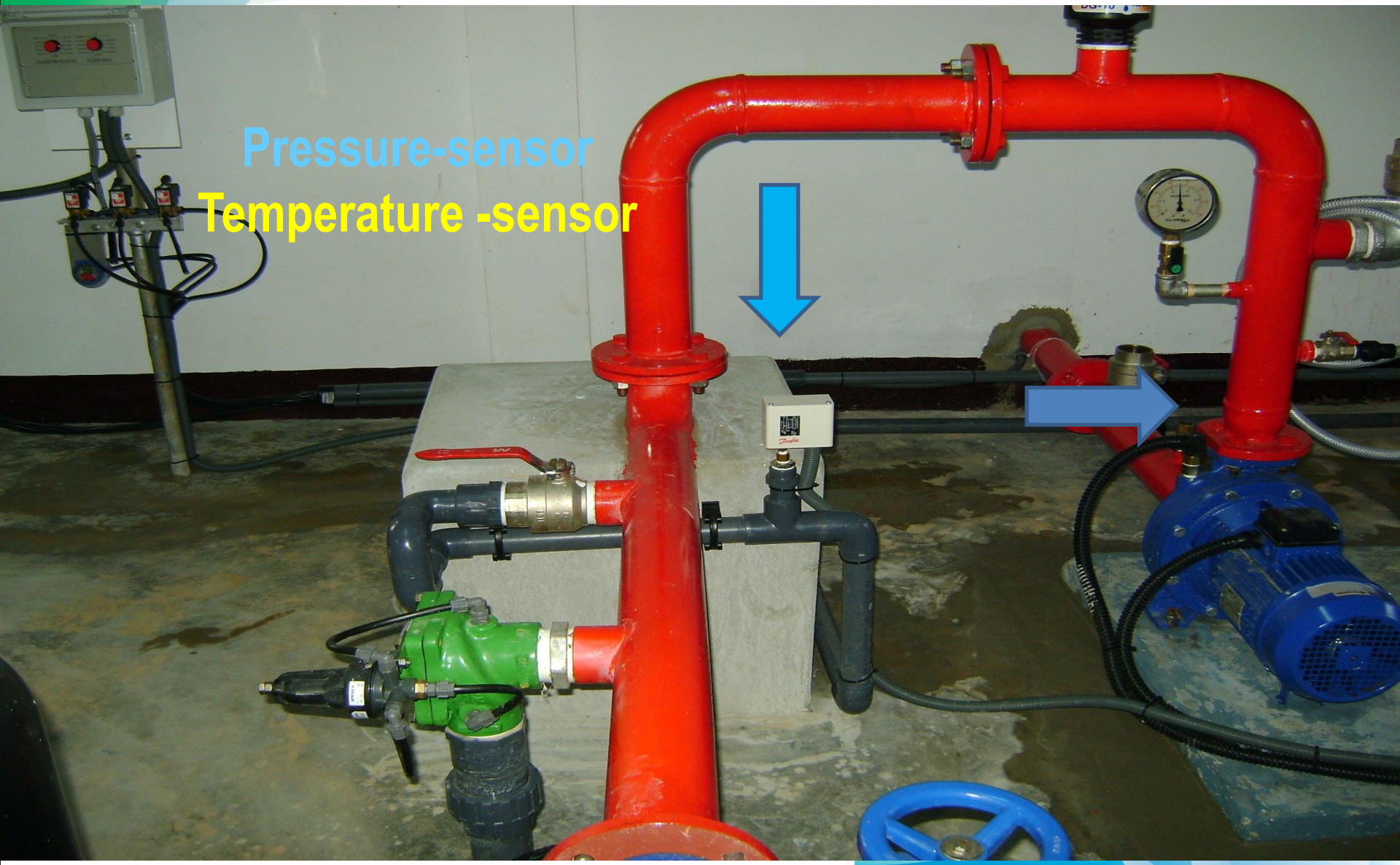
Pump base

Penjelasan Floating base : Pondasi pompa tidak menyatu dengan lantai rumah pompa untuk meredam getaran

Compulsory hydraulic devices



Assembly Delivery system


Pressure-sensor
Temperature -sensor

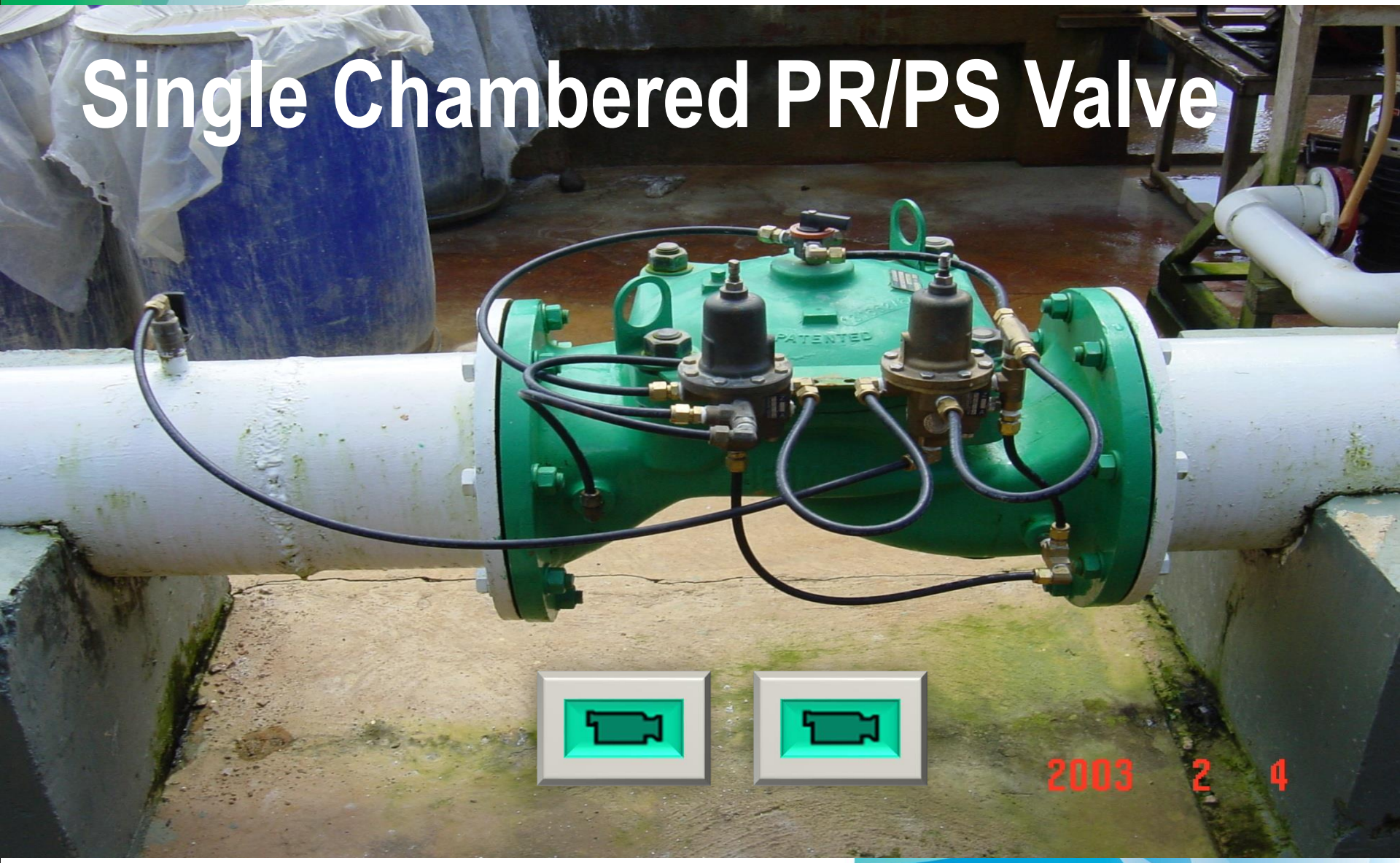
Assembly hydraulic devices

Pressure gauge

Filtration (Screen) at pump station

Filtration (Disk) at pump station

Single Chambered PR/PS Valve



CONTROL & PUMP STATION

Control station GH's

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Thank You