PUMP CONSTRUCTION

All Pratissoli high pressure pumps are of a three plunger pump design, available in 8 different ranges; each range available in different plunger diameters for a total of 41 standard models.
In addition, AISI 316 s.s. valves and heads are available for most models to suit special applications.
Aluminum bronze heads are also available for the KL pump range (KLA).

Standard versions - material of construction:

Fluid end casting:	Chemical nickel-treated spheroidal cast iron
Valves assembly:	AISI 431 s.s. (bronze spacers for KL-MS)
Plungers:	Stainless steel with ceramic coating (full ceramic for VH and SH pumps).
Pressure packings:	V-shaped double rigid rings made of special cloth and NBR rubber.
Crankcase:	Cast iron
Crankshaft (up to 40 HP):	Forged steel, hardened, tempered and nitrided.
(above 40 HP):	Machined from a solid steel bar, then hardened and tempered.
Connecting rods:	Forged steel with antifriction bearings.

Special versions - materials of construction:

The special versions are all marked with a letter after the pump name. The letter can be:

Z = Pump head and valves are entirely made of AISI 316 s.s.
The maximum operating pressure is 1160 PSI.

N = Pump head made of AISI 316 s.s. and valves made of the same AISI 431 s.s. used for the standard versions.
The operating pressure can be brought up to the standard valves.

A = Pump head made of aluminum bronze and valves made of AISI 316 s.s.
The maximum operating pressure cannot exceed 1160 PSI.

Model	EKL	HD	KL	MS	LH
AISI 316 up to 1160 PSI	EKLZ	---	KLZ	MSZ	LHZ
AISI 316 above 1160 PSI	EKLN	HDN	KLN	MSN	LHN
Aluminum bronze up to 1160 PSI	---	---	KLA	---	---

All A - N - Z pump versions feature marine resistant paint..

PUMP DRIVES

All pumps can be driven by means of pulleys / belts or flexible couplings. The bigger pumps (MS-MH-LH-SH) feature a standard gearbox available in different ratios. The other pumps are directly driven.
An option flange for hydraulic drive is available for pumps up to the MS.

	EKL	HD	VH	KL	MS	MH	LH	SH
Gear box 1500 rpm	---	---	---	---	S	S	S	S
Gear box 1750 rpm	---	---	---	---	---	---	S	S
Gear box 1800 rpm	---	---	---	---	S	S	---	---
Gear box 1900 rpm	---	---	---	---	---	---	S	S
Flange for hydraulic drive	O	O	O	O	O	---	---	---
Double shaft extension	S	S	S	S	---	---	S	S

O = OPTIONAL **S = STANDARD** **--- = NOT AVAILABLE**

PUMP THREADS

Model	**Inlet Port**	**Outlet Port**
EKL	G	G
HD	G	G
VH	G	G
KL	NPT	NPT
MS	---	NPT
MH	---	G
LH	---	G
SH	G	G

NPT - National Pipe Thread
G - BSPP (British Standard Pipe Parallel) Straight Thread

PUMP LUBRICATION

All pump crank mechanisms are splash lubricated.
No additional lubrications are required even in case of heavy continuous duty.
A greasing lubrication or water cooling system of the plungers / pressure packings is provided depending on the pump model:

Model	EKL	HD	VH	KL	MS	MH	LH	SH
Greasing lub.	S	S	---	---	S	S	---	---
Water cool.	---	---	S	---	---	---	---	S

S = STANDARD **--- = NOT AVAILABLE**

GENERAL PUMP INFORMATION

Pratissoli pumps are designed to pump (at room temperature), fresh and filtered water or other liquids compatible with the pump's material of construction and having nearly the same viscosity as water.
Nevertheless, light variations of these parameters are tolerated provided that the application complies with the below.

VISCOSITY

Light variations are allowed provided they fall within the following values:

Liquid viscosity: from 1 to 1.20 at 20°C as compared to water.

The liquid viscosity can give rise to suction difficulties so, the higher the viscosity, the more difficult the pump priming will be. For this reason, in the applications where the liquid viscosity is greater than that of water, a feed pump is compulsory. The feed pump must supply at least twice the plunger pump volume at 20 to 45 PSI pressure.

TEMPERATURE

The pump life is considerably influenced by the water temperature. The steam contained in the hot water frees itself during the suction stroke creating cavitation which then results in premature seal and valve failures.

With the water temperature from 40°C (104°F) up to 60°C (140°F) the following is to be followed:

- feed the plunger pump with a centrifugal pump, supplying at least twice the plunger volume at 25 to 45 PSI.
- reduce the pump speed, derating the RPM by at least 30% up to 50%, when necessary.
- make sure that the crankshaft turns as indicated by the arrows located near the drive shaft extension.

For operating temperatures ranging from -30°C to -40°C, the recommended crankcase oil is MOBIL SHC 630.

PUMP PERFORMANCE AND SELECTION

The performance data indicated in the catalogue refers to the maximum performance of the pump under intermittent duty. For continuous duty service, in general, the speed of the pump is to be reduced.

CONTINUOUS DUTY

- The definition of continuous duty is a pump which operates:
  8 to 24 hours per day - 7 days per week - 365 days per year

The LH pump is the only pump in the catalogue which is rated for continuous duty at the stated catalogue pump speed (i.e. at the stated maximum speed).

For all other pumps (except the LH) operating on a continuous duty, it is recommended to reduce the operating speed (RPM) anywhere from 30% to 50%.

The best practice is to reduce RPM as much as possible, using, when possible, a larger pump diameter version of the same pump series.

EXAMPLE: Customer's requirements: 12 GPM at 1740 PSI
(45 l/m - 120 bar)
According to the catalogue, the EKL22 - 1000 RPM would be the corresponding pump.

In order to reduce the crankshaft speed as much as possible (and considering that RPM and volume of a plunger pump are reciprocally proportional) we select the largest possible EKL plunger version, namely the EKL30 (*) WHICH SUPPLIES 12 GPM RUNNING AT 540 RPM.

We recommend not to operate the EKL pump below 500 RPM (see instruction manual) to prevent it from possible splash lubrication problems; this is why we did not choose the EKL32 (*) as it would have supplied 12 GPM at 480 RPM only. With regards to the lowest possible crankshaft speed please refer to the curves indicated on the individual pump data sheets.

PUMP OPERATING SPEEDS

The following are the minimum recommended running speeds for the pumps, so as to ensure that proper splash lubrication is achieved.

Model	Minimum RPM
EKL, HD VH, KL	500
MS	400
MH, LH, SH	350

INLET PRESSURE FOR CONTINUOUS DUTY PUMPS

Considering that in most continuous duty applications the pump is often unattended for long periods of time and expected to be serviced only a very few times in a year, we recommend the installation of a booster centrifugal pump in order to provide an inlet pressure of about 30 PSI (2 bar).

The correct inlet pressure provides:

- a significant increase of the pressure packing life
- reduction of the risk of cavitation
- reduction of the noise level

Note: In continuous duty applications, any accessory or instrument able to increase the whole reliability of the system is important. Reliability is the number one issue.

The losses generated by a failure of the pump or any other accessory in these cases are much higher than its initial cost.

In most continuous duty applications, a spare pump in the stand-by mode is recommended to assure no down-time.

SELECTION OF THE CORRECT BOOSTER PUMP

The booster pump must be of centrifugal type and be able to supply:

- at least twice the plunger pump flow rate
- a pressure of about 2 bar (30 PSI)

WHY TWICE THE PLUNGER PUMP FLOW RATE?

The plunger pump does not run at constant speed but is continuously accelerating after each dead center and decelerating before each dead center.

The water flow being drawn in moves accordingly and follows the acceleration / deceleration of the plunger.

Therefore at any instantaneous speed of the plunger during its stroke will correspond a proportional increase or decrease of the instantaneous flow rate.

Since the highest speed of the plunger in a crank mechanism is about 1.7 times the mean plunger speed, we realize that the plunger, for a certain period of time, BUT AT EVERY STROKE, is pumping 1.7 times the rated flow rate.

The booster pump, therefore, must ensure this extra requirement, otherwise the plunger pump will cavitate.

We state the multiplier 2 considering a safety factor of 30% for the booster pump (1.7 + 0.3 = 2).

WHY 30 PSI (2 BAR) INLET PRESSURE?

The operating principle of the plunger generates an unavoidable fluctuation of inlet pressure.

If the inlet pressure is too low, it will probably drop below zero at the maximum speed of the plunger. If it is too high it will keep the suction valves open for a longer time and let some water get back in the inlet line, thus decreasing the volumetric efficiency of the pump and increasing the pulsation level.

The inlet pressure of 30 PSI at the pump inlet has been found to be the best compromise between the two conditions.

MOTOR / ENGINE SIZING

In order to properly select the electric motor / engine which will operate the pump, apply these following formula:

Intermittent Duty:	Power (HP) =	volume (GPM) x Pressure (PSI) / 1475 volume (l/m) x Pressure (bar) / 385
Continuous Duty:	Power (HP) =	volume (GPM) x Pressure (PSI) / 1380 volume (l/m) x Pressure (bar) / 360

PRESSURE REGULATIONS

The general catalogue indicates which pump the regulators have been sized for.

The following is general information:

All the Pratissoli pressure regulators perform at least two main functions:

1. They adjust the pump working pressure from 0 up to the maximum possible pressure allowed by nozzle diameters and pump volumes.

2. They keep the working pressure adjusted and constant in every working condition (even when they by-pass the entire pump volume).

ACCESSORIES

REGULATING VALVES (RELIEF VALVES)

RV1 - RV2 - RV3 - NL2 - RX1 - RX3

These valves perform the two above-mentioned functions.

The NL2 features an incorporated by-pass lever which enables the operator to set the pressure ON or OFF without releasing the pressure adjusting knob of the valve.

UNLOADER VALVES

VU2 - AL2

Further to the two above mentioned functions, when the water flow is cut off (i.e. by closing the gun) the back pressure generated by the water flow activates the internal unloading system which eliminates high pressure in the pump.

The high pressure hose after the valve remains under pressure.

The correct performance of these valves is also related to the number of guns supplied. It is suggested not to exceed 3 guns at the same time.
As the unloading device works on the back pressure force, the higher the number of guns used the less water flow on each gun; and consequently, the less is the back pressure force generated by closing a gun.

For the correct operation, the water flow of each gun must be at least 30% of the total flow rate of the pump.

PNEUMATIC VALVES

PN/RV2 - PN/VU2

Function and performances are the same as NL2 and AL2 respectively.

Instead of the manual by-pass lever they feature a double effect pneumatic cylinder to set the pressure ON or OFF. The pressure adjustment is manual like the other valves. These valves have been designed for automatic working cycles and operated by means of an electro-pneumatic solenoid valve to supply or cut-off the air pressure.

PNEUMATICALLY OPERATED PRESSURE REGULATOR

PN3

Designed for the larger pumps, it allows the water pressure to be adjusted by proportionally adjusting the air pressure by means of an air pressure regulator and solenoid valve.

Advantages: - it allows remote control of the pressure
- it works as a pulsation dampener
- when in by-pass mode, it closes the outlet to the nozzle, thus avoiding leakage at the nozzle.

Very suitable for automatic working cycles or when frequent adjustments of the operating pressure are required.

PRESSURE REGULATORS

1. Valve and valve seat of a pressure regulator work exactly like a nozzle. The combination of large amounts of water in by-pass and high pressure **produces HIGH WEAR** of the pressure regulators. A well-sized high pressure system should pump at least 95% of the pump volume through the nozzles. The greater the volume of by-passed water, the faster the wear. Even high quality industrial regulators wear if they by-pass large amounts of water all the time.

2. **Waste of energy:** By-passed water is always wasted energy. Power is spent by the pump to pressurize the water which is then “wasted” in by-pass. In large systems that can be significant. If the customer needs to drop the operating pressure for a long period of time, he should install a larger nozzle or reduce the pump speed rather than releasing the exceeding water through the pressure regulator.

3. The velocity of the water leaving the valve is very high and the water flow is very turbulent. Do not connect the by-pass line direct to the pump inlet port.

4. Recycling: The demand for pumps and accessories able to work with recycled water is increasing. The recycled water quality, even if well filtered, gets worse and worse through the working day. The pressure regulator will wear easier than the pump. Therefore, in these applications, the pressure regulator must work in full open or full closed position only - intermediate positions should be avoided.

5. A dumping device to start the motor offload is required in most applications. Pneumatic regulators and NL2-AL2 valves are already provided with such a system. For other cases, a simple high-pressure ball tap should be installed in the pressure line, connected to the by-pass line and operated at every start up.

Two main reasons for this:

- big motors need to start offload, otherwise during the start / delta cycle they overload
- the air in the pump can get out more easily thus facilitating the pump priming.

SAFETY VALVES

SV1 - S3

They protect the system from any accidental over-pressure. In case of over-pressure, they open and discharge water in the atmosphere. They should be set at a pressure of 15% higher than the maximum working pressure of the system.

SV12

When open, it eliminates high-pressure in the system and resets automatically after the pump stops. They are supplied already set and sealed for a pressure 15% higher than the maximum operating pressure of the system. Full stainless steel construction.

The pressure should be set 15% higher than the maximum operating pressure of the system to prevent the peaks of the pressure generated by the pulsating motion of the plunger from generating leaks.

HYDRAULICALLY OPERATED VALVES

VI1 - VI3

Both valves work with the same principle.

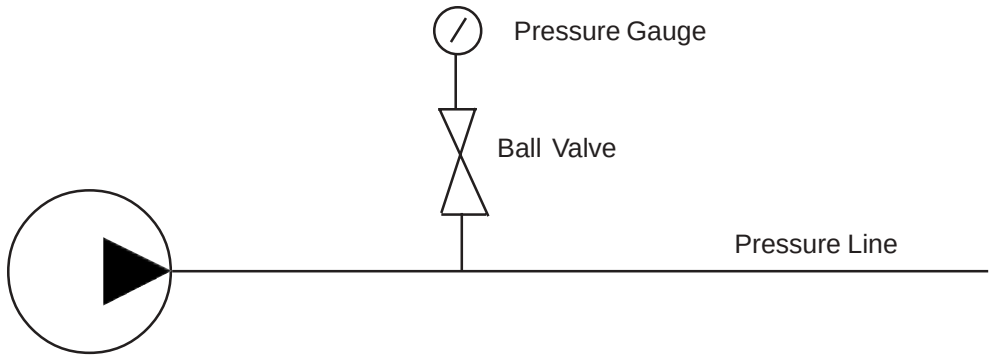
The only difference between the two is as follows:
- 2 way - T-joint installation for the VI1
- 3 way - in line installation for the VI3

The pressure adjustment is manual whereas the pressure setting (ON-OFF) is hydraulic by means of oil at 120 bar (1740 PSI).

PRESSURE GAUGES

The pressure gauge must be always of a glycerin filled type since it is more reliable for pulsating loads. The life of standard pressure gauges used with a reciprocating pump is normally shorter. The pressure gauge is a MEASUREMENT INSTRUMENT ONLY and therefore it should be used only to read the pressure when you really need to do so (i.e. when you need to set up the working pressure, for pressure checks, etc.). Working all the time is not useful (stationary equipment is generally unmanned for most of the time during the working day) and will only shorten its life.

We therefore suggest to mount a 2-way ball valve in between the gauge and the pressure line as shown below:



OTHER ACCESSORIES

DUMP GUN

P12

This dump gun is rated for pressure up to 17,400 PSI (12 bar). When releasing the trigger, the pressure is instantaneously diverted from the nozzle to the upper dump tube and then released into the atmosphere at 0 pressure. The main advantage is that it avoids the pressure peak normally generated by the conventional dry shut-off guns, thus preventing the hose and connections from dangerous hydraulic shocks. All wetted parts are constructed of stainless steel.

PS12

It is the submersible version of the P12 dump gun. It features a second nozzle spraying at the rear in order to balance the back thrust of the blasting nozzle during underwater operations, thus avoiding the operator fatigue and unsafe working conditions.

PNEUMATICALLY OPERATED DUMPING VALVE

PN12

Rated for 17,400 PSI (1200 bar) it should be mounted on the pressure line by using 2-way (T joint installation) or 3-way (in-line installation). By means of a pneumatic cylinder, it opens the by-pass line thus dumping the pressure in the system (i.e. during pump start up and automatic working cycles). The pneumatic cylinder allows smooth switching operations and protects the system from hydraulic shocks.

Note: It works on a full-open / full-closed basis, therefore it does not relieve any excess of pressure.

FOOT VALVE

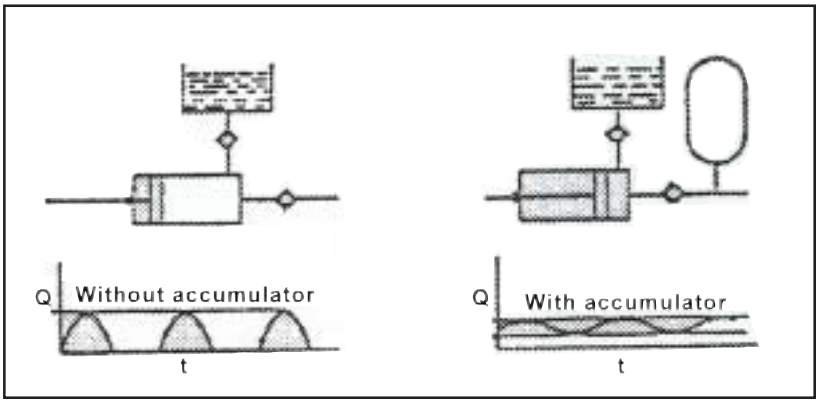
VP12

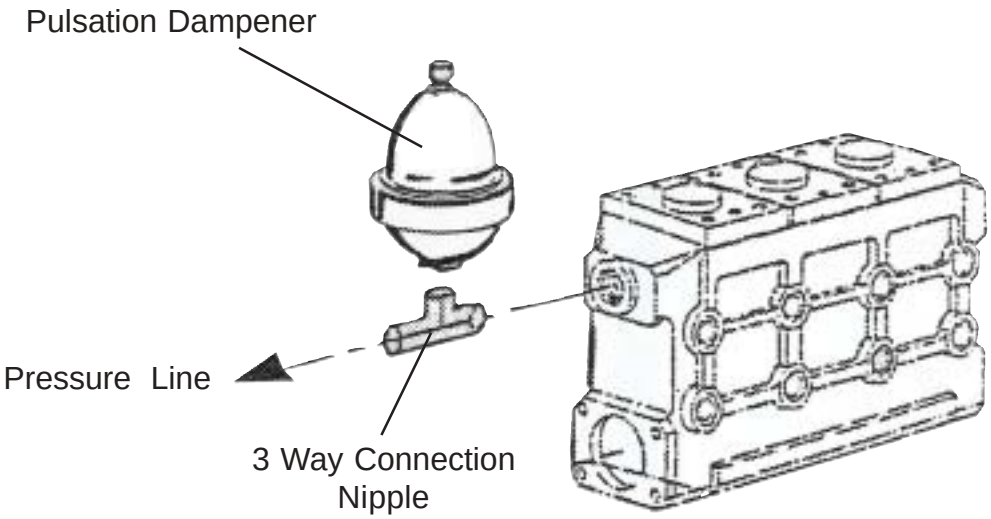
Developed to facilitate internal cleaning of pipes and tubing with flexible or rigid long lances. The pressure foot system leaves both hands free for easy control of the lance during operation inside heat exchangers and tube bundles. When released, the internal by-pass system diverts the flow from the nozzle to the by-pass line, thus eliminating high pressure in the system instantaneously without any hydraulic shocks.

PULSATION DAMPENERS

A pulsation dampener is required for most of the pumps, especially those versions of each series having large plunger diameters. Its function is to dampen the maximum peak of pressure generated by the reciprocation motion of the three plungers which could give rise to resonance and vibrations on the pipeline. Every pulsation dampener is nitrogen pre-charged before shipment according to the working pressure of the pump for which it has been selected. Therefore, when ordering a pulsation dampener, the working pressure must always be specified. The pre-charge pressure has to be about 70% of the pump working pressure. This value allows the highest efficiency. The pre-charge pressure should be constantly checked.

- The first check should be done within the first week of service. The following checks should be done on a monthly basis.





PUMP INSTALLATION

POSITIONING

The pump must be fitted on a rigid and perfectly flat base by means of the proper four feet. The maximum pump inclination during operation should not exceed 5° so as to guarantee the correct splash lubrication. The base must be rigid enough to avoid any misalignment or flexing on the pump / transmission coupling axis due to the torque involved during operation. Under no circumstances should the pump be fitted in such a way that its fluid end rests on the base. The fluid end must be left free and not subject to any forces.

DIRECTION OF ROTATION

- clockwise with shaft projection on the left side
- counter-clockwise with shaft projecting on the right side

HYDRAULIC CONNECTIONS

In order to isolate the pump vibrations from the rest of the plant, it is suggested, where applicable, to fit flexible hoses for both suction and discharge lines at least for the first lengths. The flexible suction hose should be rigid enough to avoid contraction caused by the depression generated by the pump during the suction stroke.

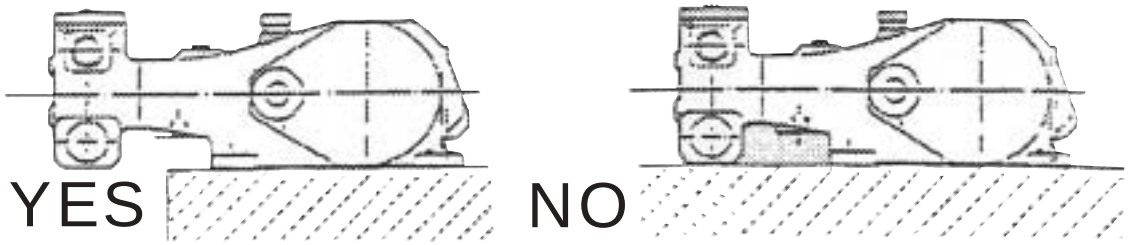
PUMP FEEDING

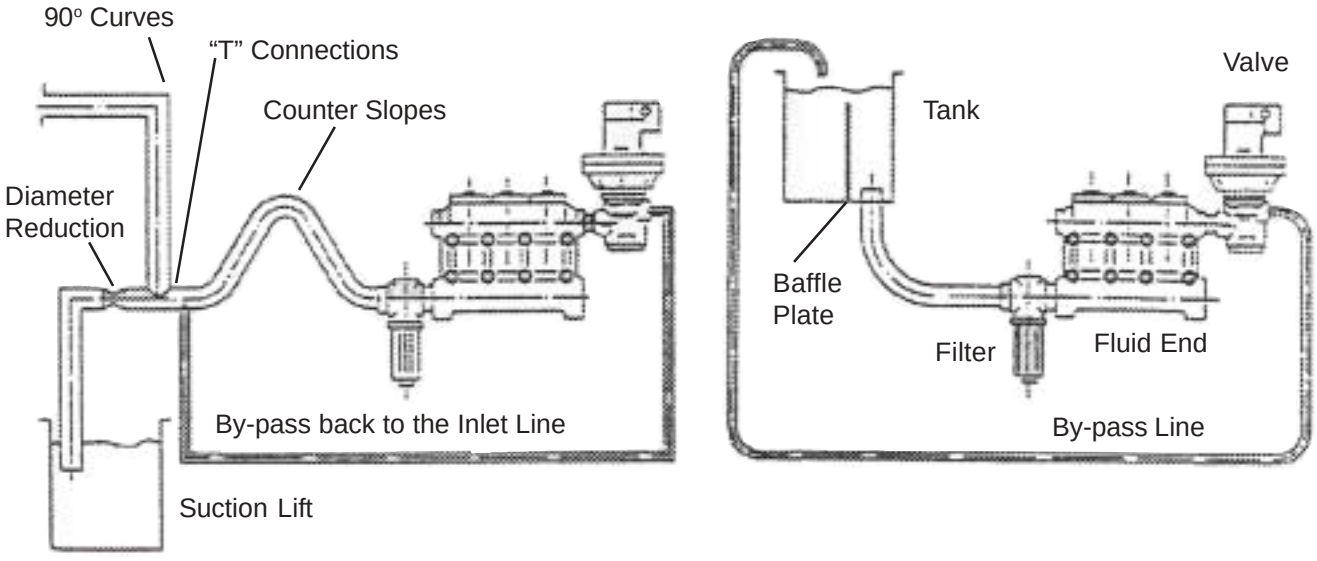
Plunger pumps are not self-priming and, for this reason, must always be installed with a positive suction head. THEY MUST NEVER BE OPERATED WITH A SUCTION LIFT, otherwise cavitation will occur. In the case of continuous duty, a very long suction line or when hot water is involved (up to 60°C), the installation of a centrifugal feed plump is strictly recommended. The feed pump must supply at least twice the plunger pump volume at 1 to 3 bar (15 to 45 PSI), be operated independently and supply its full rated performance even if the plunger pump is below its rated performance.

SUCTION LINE

The pump life is considerably influenced by the effectiveness of the suction line, which MUST HAVE THE FOLLOWING CHARACTERISTICS:

- the internal diameter of the suction line must be at least of the same size of the pump inlet port. The diameter is to be increased according to the pressure due to the length and shape of the line
- it must be as constant as possible and positioned in such a way to facilitate air pockets and bubbles to escape
- it must be perfectly airtight
- it must be completely free of 90° elbows, diameter reductions, counter slopes, “T” connections and must not be connected with other pipelines.
- it must be positioned in such a way to avoid the pipe from emptying itself of fluid after the pump stops


YES
NO


90° Curves
"T" Connections
Counter Slopes
Diameter Reduction
By-pass back to the Inlet Line
Suction Lift
NO
Valve
Tank
Baffle Plate
Filter
Fluid End
By-pass Line
YES

RECOMMENDATIONS

- do not use high pressure flexible hoses as suction lines.
- do not use high pressure hydraulic fittings like 90° elbows, high pressure adapters, high pressure 3 or 4 way nipples and so on.
- do not fit along the suction line any kind of detergent injector.
- do not fit standing valves, check valves or other kind of one-way valves.
- when using a feeding tank, make sure that the dimensions of the tank and the water minimum level do not give rise to turbulence at the tank outlet port, which, in turn, might create cavitation at the pump.
- do not connect the by-pass line from the valve directly to the pump suction line.
- when using a feed tank, connect the by-pass line from the valve directly to it and make sure that both the by-pass and tank feeding flows will not give rise to turbulence at the tank outlet port, which, in turn, might create cavitation at the pump. Proper baffle plates should be provided inside the tank.
- before connecting the suction line to the pump inlet port, make sure the pipe is perfectly clean inside.

FILTRATION

All pumps require a suitable filter. The filter should be installed as close as possible to the pump, and should allow easy inspection and have the following characteristics:

- the filter capacity must be at least three times the rated pump volume
- filter port diameters must not be smaller than the pump inlet ports
- filtration is to be between 50 and 80 mesh (360 - 200 microns)

Important Note:

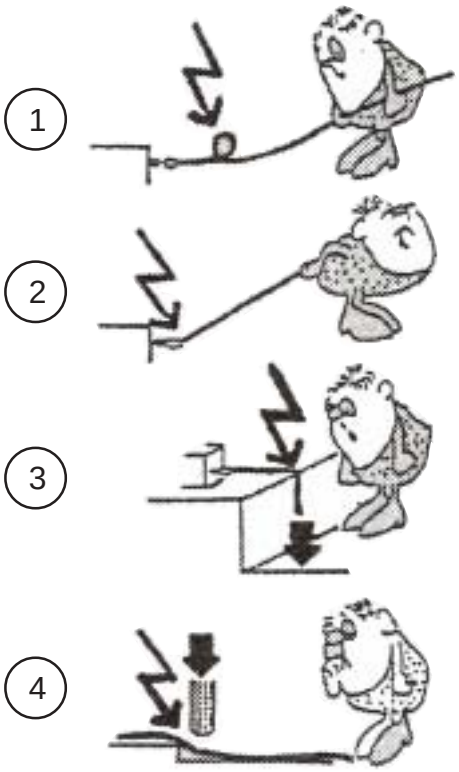
In order to properly safeguard the pump, it is very important to plan frequent maintenance schedules to be carried out according to the water quality, degree of filtration and number of hours of each application.

DISCHARGE LINE

To ensure that the discharge line is correct:

- the first length of discharge hose must be made of a flexible type in order to isolate the pump vibrations from the rest of the plant
- use only high pressure hoses and fittings able to guarantee the largest possible safety margins in any working condition
- a suitable relief valve must be fitted on the discharge line
- always use glycerin filled pressure gauges, as they are the most suitable for pulsating loads
- when designing the discharge line, take into account the unavoidable pressure drops at the nozzle, due to the length and size of the discharge line
- if necessary, the effects of the pump pulsations can be reduced by installing a proper pulsation dampener on the pressure line
- if the high pressure system is controlled by an unloader valve, the installation of a pulsation dampener is recommended.

WARNINGS FOR SAFE USE OF HIGH PRESSURE HOSES



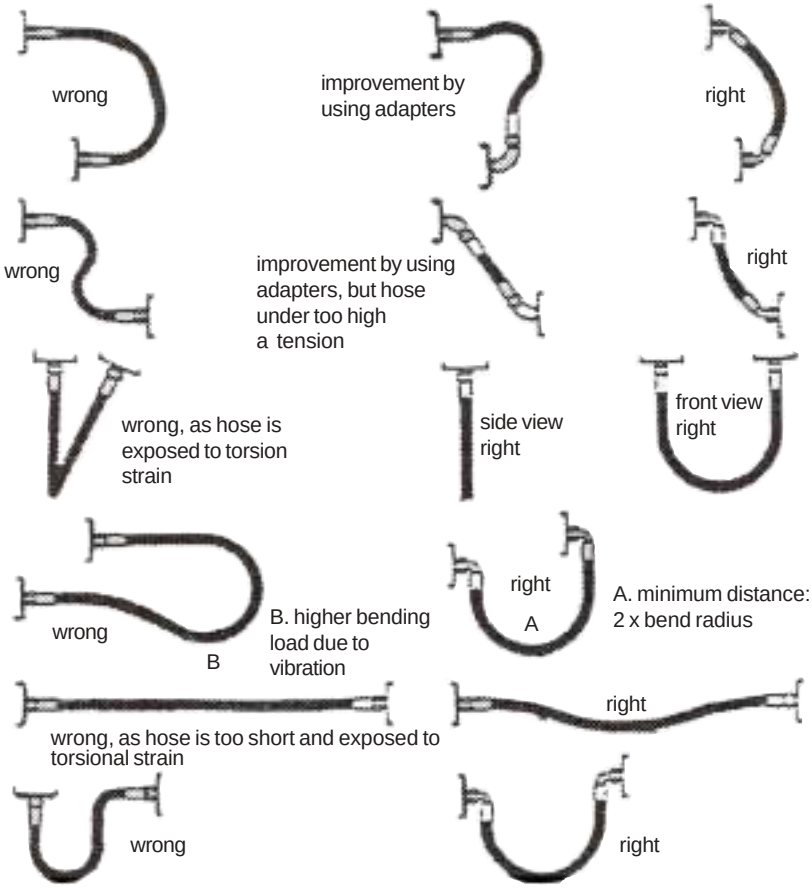
1. ***Loop formation during operation***
   Avoid loops! If a loop occurs during operating, immediately switch OFF the high pressure unit and carefully clear away the loop.

2. ***Hose tube as traction rope***
   By no means is the hose to be used as traction rope for moving the high pressure unit!

3. ***Sharp edges, buckling***
   Never lead the high pressure hose around sharp corners or buckle it in any way.

4. ***Crossing by vehicles***
   Principally high pressure hoses must never be point loaded (e.g. being run over by vehicle). In such cases the wire or textile reinforcement and the hose is destroyed.

HOW TO INSTALL THE HIGH PRESSURE HOSE



When designing and mounting hoses, one has to take care of the following:

a) collapsing stress occurring just after the fittings should be avoided, if possible apply steel protection coil spring.

b) always keep the right bend radius.

c) never install hoses in a way that tensile strain will occur.

d) torsional strain occurring by twisting the hose should also be avoided.

BEFORE START UP

Before starting up the pump, make sure that the following conditions have been met:

- suction line must be connected to the pump: the pump must never run dry.
- suction line must be perfectly airtight.
- any ON-OFF valve in between pump and water source must be open and make sure the water gets into the pump freely.
- set the pressure line in dump mode in order to let the air in the pump to get out easily thus facilitating the pump priming.
- make sure all suction / discharge line connections are fully tightened.
- joint alignment, belt tightening and P.T.O. shaft inclination tolerances must be within the values indicated by the transmission manufacturer.
- make sure of the correct oil level.

STARTING UP

- pump and motor / engine must start offload: set the regulating valve to zero or set the pressure line in dump mode by means of proper dumping devices.
- when starting the pump up for the first time or after every wiring re-connection check for proper direction of rotation.
- during operation, check that the rotating speed does not exceed the rated value.
- before putting the pump under pressure let it run for some time until the oil flows freely.
- before stopping the pump release the pressure from the system by operating the dump device or by releasing the regulating valve and reduce RPM to a minimum (diesel applications).

Note: In case of feeding by a centrifugal pump, make sure that the plunger pump starts only when the correct inlet pressure is provided.

WATER LEAKAGE

During operation, a small amount of water (a few drops a minute) is released from the pump fluid end. This leakage is designed to provide lubrication for the pressure packings. The leakage is drained out of the pump through a hole. This hole must always be left open.

TROUBLESHOOTING

THE PUMP DOES NOT PRODUCE ANY NOISE AFTER STARTING UP:

- the pump is not primed and is running dry!
  - no water in the inlet line.
  - the valves are blocked.
  - the pressure line is closed and does not allow the air to get out of the fluid end.

THE PUMP KNOCKS:

- air being sucked in at inlet
- insufficient water supply:
  - bends, elbows and fittings along the suction line throttle the amount of flluid which passes through.
  - too small an inlet filter.
  - dirty inlet filter.
  - the feed pump, where provided, is not of a suitable type or provides insufficient pressure or volume.
  - the pump is not primed due to insufficient feed or the discharge line is closed during start up.
  - the pump is not primed because some of the valves are stuck (i.e. pump inactivity for long time).
- jammed or worn-out valves.
- worn-out pressure packings.
- the pressure regulating valve does not work properly.
- insufficient clearance in the drive system.
- RPM is higher than rated.

THE PUMP DOES NOT DELIVER THE RATED VOLUME:

- insufficient feed (due to the causes listed above).
- RPM is less than rated.
- excessive amount of water by-passed by the pressure regulating valve.
- worn-out valves.
- excessive leakage from pressure packings.

INSUFFICIENT PUMP PRESSURE:

- the nozzle is (or has become) to large (i.e. worn).
- RPM is less than rated.
- excessive leakage from pressure packing.
- excessive amount of water by-passed by the pressure regulating valve or faulty valve operation.
- worn-out valves.

EXCESSIVE WATER LEAKAGE FROM THE PUMP:

- pressure packings are worn-out (due to normal wear or excessive cavitation).
- worn-out plungers.

TROUBLESHOOTING (continued)

OVERHEATED PUMP:

- the direction of rotation is not correct.
- the pump is overloaded (pressure or RPM over the rated valued).
- the oil level is too low or the oil is not of a suitable type or fully used.
- water in the oil.
- excessive belt tension or incorrect alignment of the joint (where provided).
- excessive inclination of the pump during operation.

PIPE VIBRATIONS OR KNOCKING:

- air being sucked in at inlet.
- the pressure regulating valve is not working properly.
- the by-pass line is undersized.
- jammed up valves.
- drive transmission motion is irregular.

GENERAL WARNINGS FOR SAFE OPERATION

The misuse of a high pressure water unit and the non-observance of the pump installation and maintenance instructions may cause serious damage and / or injuries to people or property or both.

Any Manufacturer / Operator requested to assemble / use a high pressure water unit should be competent to do so, should have the necessary knowledge on every high pressure component installed in the unit and on the precautions to be taken in order to guarantee the largest safety margins during operation. No precaution, so far as is reasonably practical, should be left out in the interest of safety, both from the Manufacturer and the Operator.

HIGH PRESSURE UNIT SAFETY REQUIREMENTS

- a safety valve should be installed in any discharge line and should be sized to discharge or by-pass the entire pump flow rate.
- high pressure unit components, with particular regard for those units working outside, should be adequately protected against rain, frost and heat.
- electric components and wiring should be provided with an adequate degree of protection, able to protect themselves against spray coming from any direction.

They should also be suitable for working in a wet environment.

- high pressure hoses and any other accessory under pressure should be sized in accordance with the maximum unit working pressure and must always work within the safety margins indicated by the hose / accessory Manufacturer.
- high pressure hose ends should be fastened to a steady body in order to prevent them from dangerously sweeping around, should they burst or come off their end fittings.

- proper safety guards should be provided to adequately cover transmission joints, pulleys, belts, auxiliary drives.

SAFETY OF OPERATIONS

The access into the area where a high pressure unit is working should be strictly prohibited to unauthorized personnel. The area should be suitably enclosed and its perimeter, so far as is reasonably practicable, cordoned off and proper warning notices displayed in prominent positions.

Personnel authorized to enter that area should have been previously trained to do so and informed of the risks arising from failures, misuse and any forseeable circumstance which may occur during operation. Before starting the pump unit and bringing it up to pressure the Operator is requested to carry out the following checks:

- make sure that a correct water supply to the pump is provided.
- make sure that water inlet filters are properly clean.
- electrical components and wire, with special emphasis on connections, junction boxes, switches and supply cables should be free from external damages (i.e. exposed and broken wires) and adequately protected against water.
- high pressure hoses should not allow apparent external wear and the fittings at both ends should be free from signs of erosion or corrosion.
- make sure that all fluids (lubricating oil for pump and engine, cooling water, hydraulic fluids) are at proper level and in good condition.
- make sure the safety guards are in good condition.

The work should stop immediately and the pressure must be released in the event that leakages become apparent or if any person becomes aware of any change in condition or any hazard existing or being introduced.

Any failure must be promptly reported and then checked by competent personnel.

GENERAL PROCEDURES FOR HIGH PRESSURE GUN / LANCE USE

- the Operator should take reasonable care for the safety of himself and of other persons who may be affected by his acts or omissions at work. His actions should be always governed by his good sense and responsibility.

- the Operator should wear suitable waterproof protective clothing, having regard to the type of work being undertaken. The clothing set should include adequate hand protection, suitable boots able to ensure proper grip on wet floors, helmet provided with full face shield, water proof garment providing full cover to the Operator, including his arms.

As most water jets produce noise levels in excess of 90dB(A), suitable ear protection is strongly advised.

GENERAL PROCEDURES FOR HIGH PRESSURE GUN / LANCE USE (continued)

Note: It must be emphasized that whereas protective clothing provides adequate protection against spray and flying particles, it does not constitute complete protection against the direct impact of the water jet. Additional protections in the form of suitable metal shields or barriers may be necessary for certain jetting operations.

- in most jetting operations, it is accepted practice to employ a team of Operators consisting of two members at least, in order to provide mutual assistance in case of need and to rotate their duties in case of long and heavy work. While the first Operator holds the gun, the second Operator attends to pump unit, keeping close watch on the first Operator for signs of difficulties or fatigue, and watching the surrounding area for intrusion by other persons or unsafe situations. If required, he will shut off the pressure unit until it is safe to continue.

- the area in which the work is to proceed should be clear of loose items and debris to prevent tripping and slipping hazards

- the water jet should be directed only and always against the work piece, even during preliminary operating tests prior to starting work.

- where applicable, proper side shields should be suitably placed to safeguard personnel and equipment against contact with grit or particles removed by the water jet.

- on no account must the Operator be distracted during operation until the jet has been stopped.

Personnel having reason to enter the water jetting area should wait until the jet is stopped and his presence is known.

- each team member must always be aware of the actions and intentions of other team members in order to prevent any dangerous misunderstanding occurring during jetting operation.

- the pump unit should not be started and brought up to pressure unless each team member is in his designated position, the nozzle directed to the work piece and the lance or gun securely held.

SAFETY OF MAINTENANCE

- apart from the working pressure regulation no attempt should be made to adjust any nut, hose connection, fitting, etc. while that part of the system is under pressure. The pump should be stopped and any pressure in the line released prior to making any adjustment.

- the high pressure water unit should be maintained in accordance with the Manufacturer's instructions.

- the high pressure water unit should be maintained only by competent personnel.

- service and maintenance should be carried out with the proper tools in order to prevent any damage on high pressure connections and fittings.

- use of other than Pratissoli original spare parts is strictly forbidden.