

A compact means of boosting production

Framo water injection pumps

The Framo advantage

At Framo, we're driven by the simple idea that pumps should never be isolated from the task they perform. It's a belief that revolutionized marine cargo handling. And today it's creating new possibilities for faster, safer and more profitable business in the oil and gas industry.

It's also an idea backed up by experience. Framo has proud roots that stretch back to 1938, and marine customers have put their trust in our unique pumping technology for over 50 years.

But even more important is the trust that customers place in us. That's why we see our designs through from start to finish at our own facilities in Norway, where we test each project in full scale before delivery.

Framo customers know they receive full support throughout the service life of their equipment. No matter the problem, our experts can be dispatched 24/7 to any location worldwide, and they stay until the issue is resolved.

With a global organization of 1200 dedicated employees, we are a partner you can rely on.





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Water injection pump system

Overall design philosophy

The overall design philosophy has been to provide:


- High flexibility regarding adjustments to changing reservoir requirements and maintained pump performance. By the use of machined high performance impellers, it is possible to change the design point within one offshore shift
- Integrated booster pump, with low NPSH requirement
- Minimum weight and space requirements, both with regard to basic footprint and service space
- Minimum service down-time, with change of complete impeller set possible within one shift
- High pump reliability with an inherent mechanical simplicity

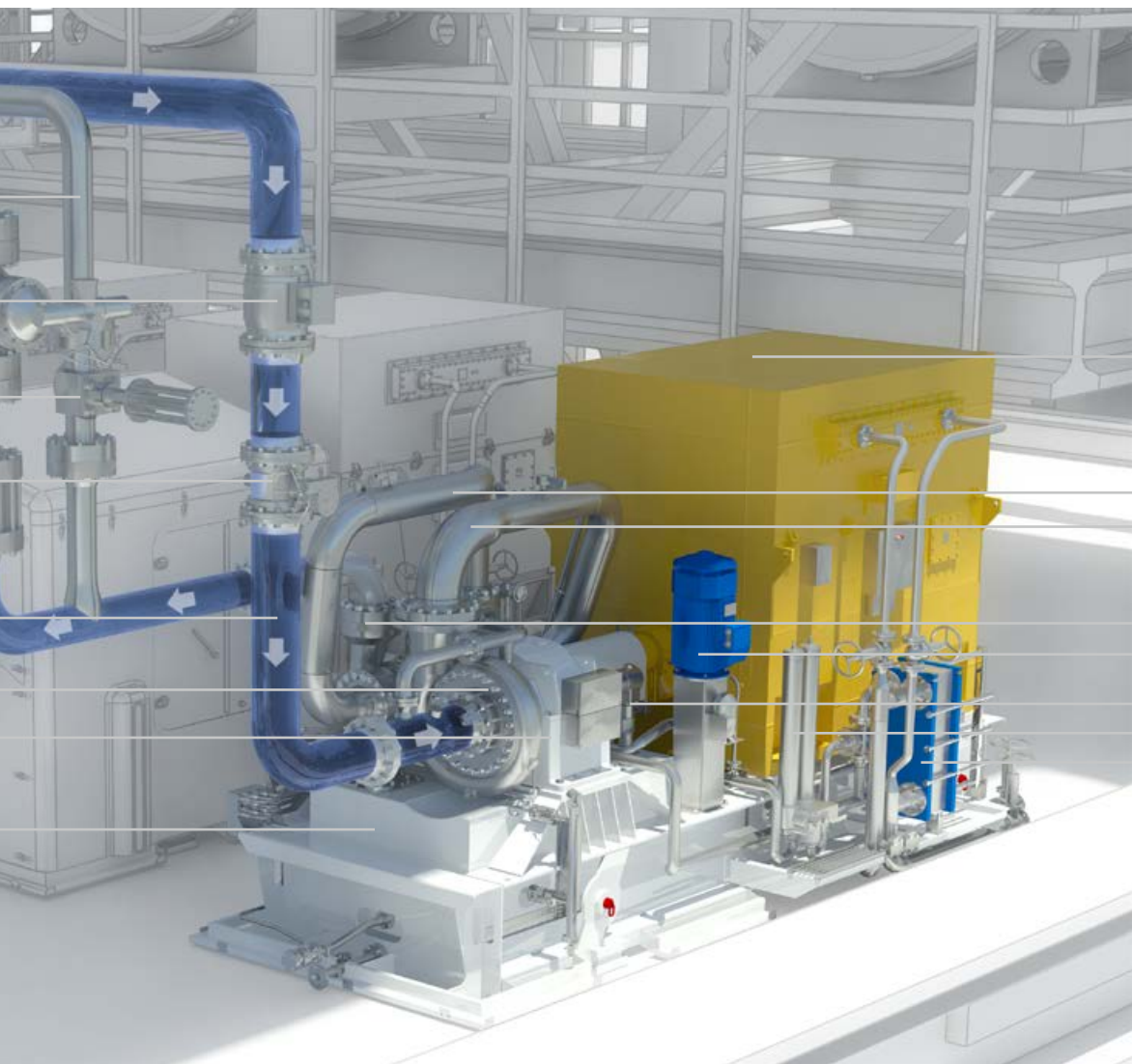
Conceptual description

The water injection pump unit consists of a booster pump stage and two high-speed injection pump stages, driven by a common driver over a spacer coupling and a gearbox.

The gearbox is built as an integrated part of the injection pump unit, and the outgoing shafts include bearings and mechanical seals for the pumps as well as direct coupled impellers in each end.

Control of the package is maintained from a central control system or a local control panel with a minimum number of sensors on the pump and driver unit.

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- Discharge manifold
 - Minimum Flow manifold
 - Flowmeter
 - Discharge valve
 - Discharge valve
 - Isolation valve
 - Check valve
 - Suction manifold
 - Integrated booster pump
 - Gearbox
 - Lube oil tank



- Electric motor
- Crossover pipe
- Link pipe
- High pressure pump
- Auxiliary lube oil pump
- Main lube oil pump
- Duplex lube oil filters
- Lube oil cooler

Basic hydraulic design

Booster pump

The booster pump section of the water injection pump consists of a double-volute, single-stage centrifugal pump.

The pump is driven over a step-down of gearwheels inside the same gearbox as the high-speed pump stages, in order to give optimum suction performance.

The impeller is of radial design with a low NPSH requirement.

HP pump

The high-speed section of the water injection pump consists of two single stage HP pump units mounted back to back on a common shaft.

The HP impellers are a machined high performance type of radial design, with high head capacity, and single suction as a function of the design.

A double-volute pump casing design is utilized. This is done for three basic reasons, all pointing in the same direction:

- Specific speed (NQ) of the pump is within the area, giving the best performance with a volute casing
- A volute casing gives low complexity of the construction and a wide operating envelope
- A volute casing gives good maintainability

The double-volute casing design is selected to give the pump good radial balancing. The two single-stage units mounted back-to-back also balance the thrust forces in the pump, by the design of impeller wear-rings.

The solution

Framo HP water injection pumps consist of a centrifugal booster pump stage and two high-speed injection pump stages. The pump stages are driven by a common driver, and the pumps and gearbox are built as an integral unit with combined shafts/bearings. The HP pump stages consist of two single centrifugal pump units mounted back-to-back on a common shaft.

The HP impellers are fitted on the output shaft with an interference fit and two symmetrical key-ways. The design allows individual, balanced impellers to be fitted on site without rebalancing the entire rotating assembly. This contributes to high serviceability and performance flexibility of the unit. The short overhang and short shaft design results in a stiff and robust unit with operating speed well below first critical speed. Single and double mechanical seal systems are available depending on the pump application.

Produced water

Produced water reinjection is frequently practised to reduce discharges to sea. However, pumping produced water is a challenge due to sand contamination and various chemical characteristics of the water. Our pumps employ wolfram carbide wear surfaces in combination with standard double mechanical seals with liquid barrier fluid, proven very successful in handling produced water reinjection.

Service maintenance

The compact, low-weight design gives easy access to rotating components in the pumps. As a result, replacing impellers, wear rings and mechanical seals can be performed in one

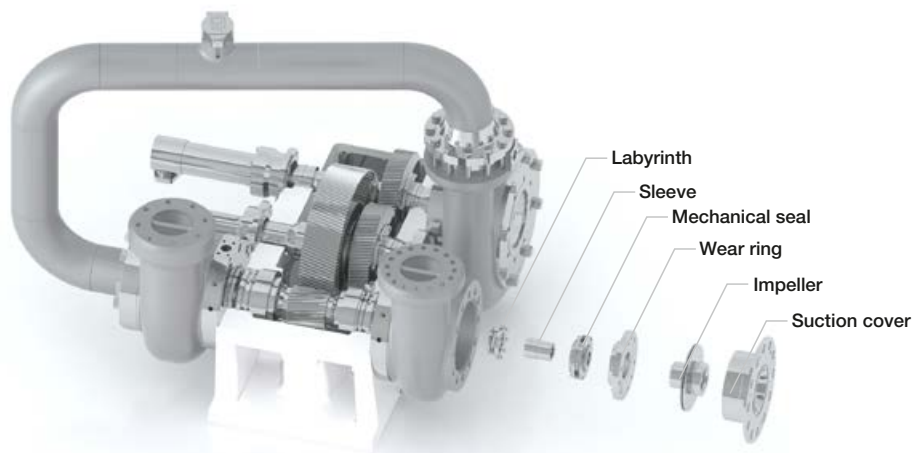
offshore shift, offering the shortest downtime for any large water injection pump, with the added advantage of minimum service space and lay-down area requirements.

The high pressure pump impellers weigh 10-20 kg. By changing the type of impeller, the same pump can perform both normal injection and reservoir fracturing operations. Exchanging an impeller and mechanical seal can be carried out in less than one shift from pump shutdown to start-up.

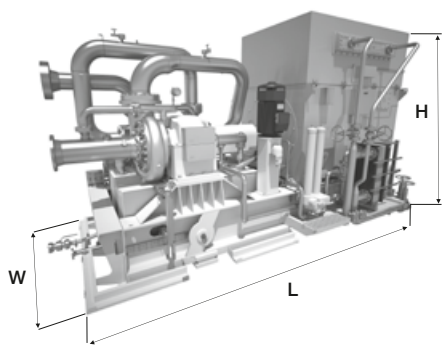
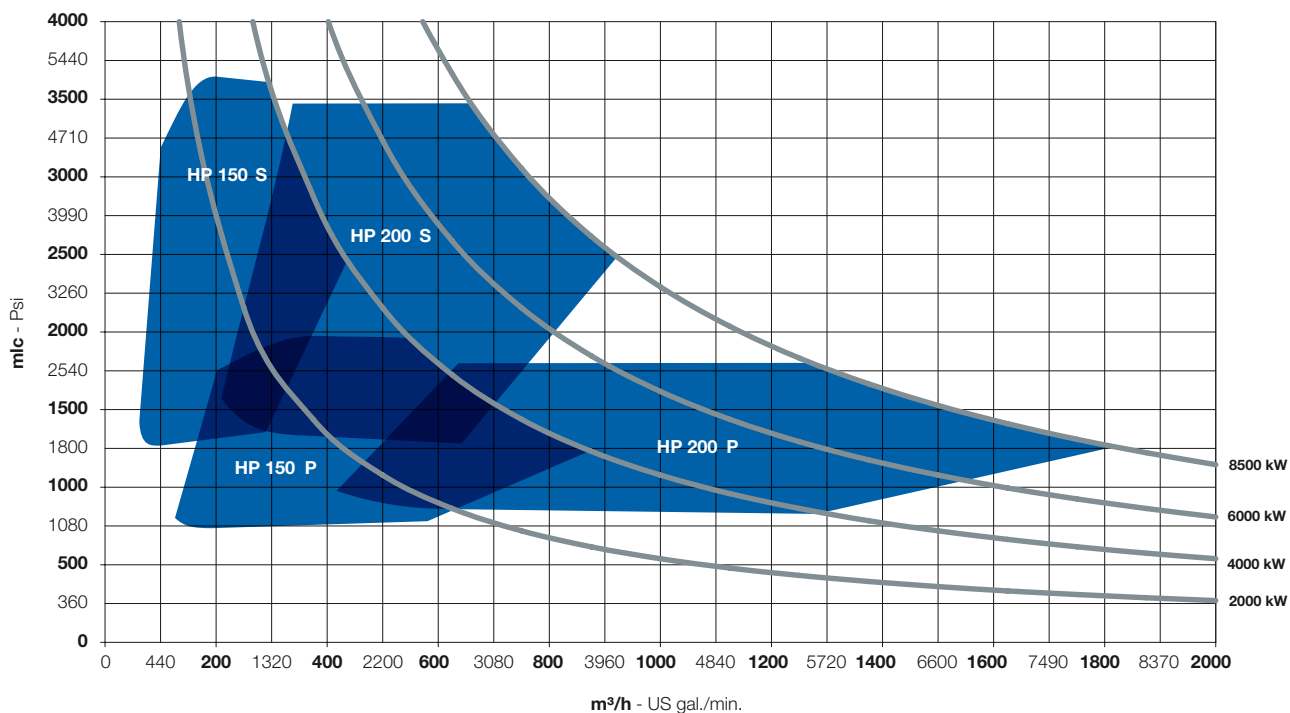
Performance flexibility and string testing

High performance, machined impellers cover each of the pump operating envelopes, hence a different pump duty can be achieved at short notice within the available motor rating by changing impellers.

All Framo water injection pump systems are fully factory tested at the rated conditions of capacity, head and speed. New impeller designs are always tested for net positive suction head (NPSH), using flow visualisation at rated flow and speeds, enabling pump performance guaranteed beyond the normal API test requirements for a particular application.



Technical data



Pump type / Rating	Length [m]	Width [m]	Height [m]	Weight [kg]
HP150/1000	4.6	2.6	2.5	14200
HP150/2000	4.75	2.6	3.3	17200
HP150/3000	4.9	2.6	3.3	18500
HP150/4000	5.1	2.6	3.3	19200
HP200/5000	5.6	2.9	3.7	24900
HP200/6000	5.8	2.9	3.7	29000
HP200/7000	6.0	2.9	3.7	30000
HP200/8500	6.2	2.9	3.7	33000

Note: The range chart and the data table show the normal operating range. However, for special cases, the pumps can be modified to cover duties outside this range.

Mechanical design

The water injection pump and step-up gearbox are built as an integrated unit with combined bearings for gearbox output and pump shafts. The HP impellers are directly fitted on the output shafts, with a light interference fit and two symmetrical keyways.

The booster impeller design allows individually balanced impellers to be fitted on the shaft on site without rebalancing the complete rotating assembly. This further contributes to the good serviceability and performance flexibility of the unit. The short overhang of the impeller shaft combined with generously sized bearings provides a very stiff and rugged rotating element with a speed well below first critical speed.

At running condition, the distance to the first critical speed is even greater due to the dampening effect of the water between the wear-rings.

The gearbox is designed for indefinite life in accordance with the practice of the compressor industry that for years have been operating at high speeds with a minimum of gearbox problems. The gear standard used is ISO 1328 quality class 5. The maximum peripheral speed of the gear is approx. 90 m/sec. This is a comfortable distance from the recommended max. 127 m/sec., given for indefinite life with the actual load, lubricated conditions, application factor and materials.

To eliminate fixing and sealing difficulties under the high differential pressure and high rotational speeds of the pump, integral impeller wear rings are formed by overlaying the wear ring area with wolfram carbide. The casing wear-rings also have a wolfram carbide overlay, ensuring excellent concentricity and wear properties.

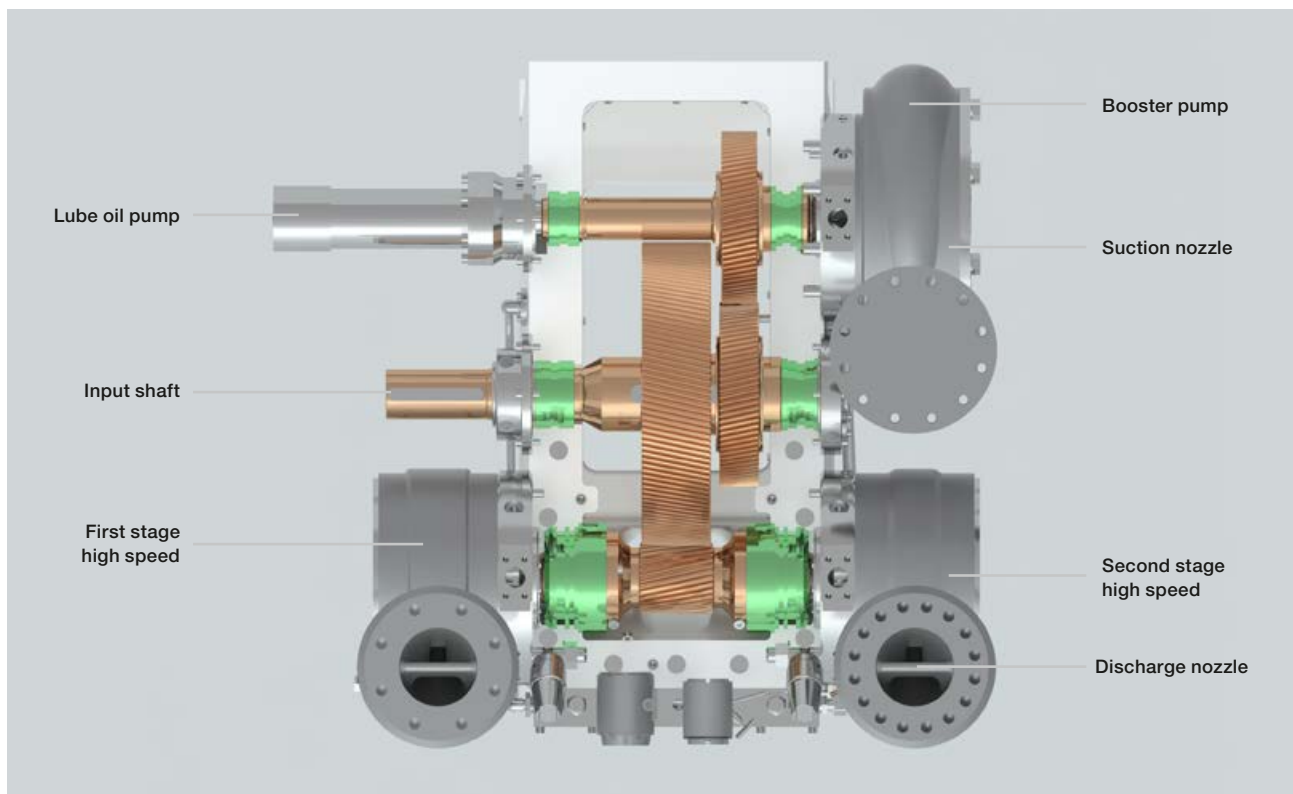
Bearing system

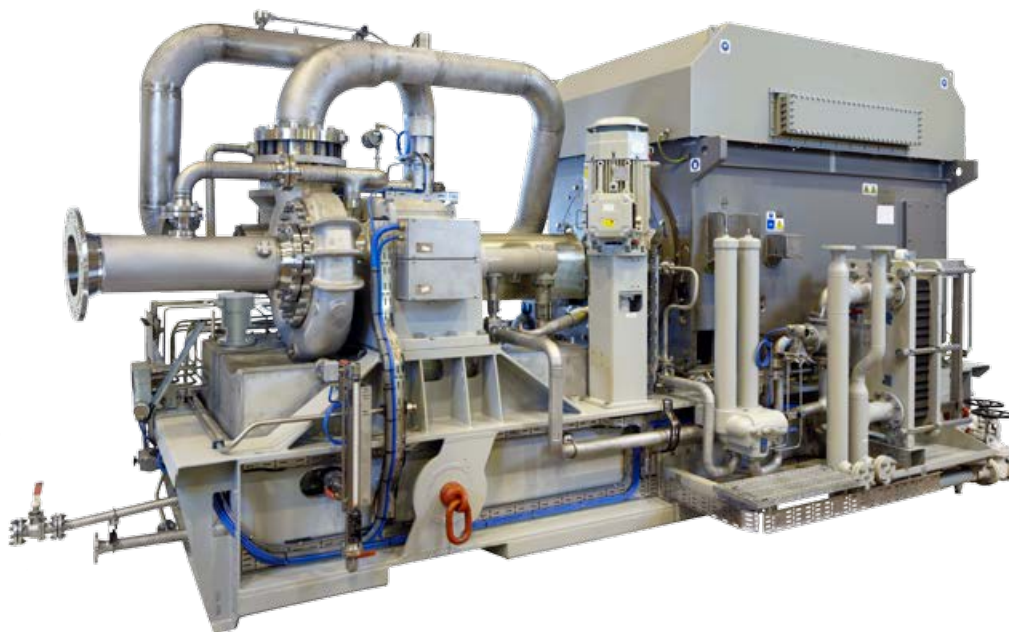
The bearing design for the pump and gearbox shafts, as shown on the conceptual drawing below, combines thrust and radial bearing types.

The bearings are selected based on a bearing computer calculation programme developed by Advanced Bearing Technology Ltd. Both for the radial and thrust bearings, compensated tilting pad types are selected for worst case load parameters.

The large diameter radial bearings ensure optimum load-bearing capacities and vibration levels within recognized standards.

The conceptual solution with the two single impellers back-to-back allows hydraulic balancing of the impellers to cater for varieties in thrust, due to wear and running in off-duty conditions. The thrust bearings have, however, been designed with good margins to worst case conditions.





Double mechanical seals

For produced water applications, the water injection pump utilizes double mechanical seals with an integrated barrier fluid system. The barrier fluid prevents any leakage from the process fluid to the gearbox or atmosphere.

The mechanical seals are working against a differential pressure of 10-15 bar and are over-pressurized by a closed loop barrier system. This means that a controlled leakage from the barrier fluid always will be present, giving optimum operation conditions for the seals. In addition to enhanced protection of the gearbox, the barrier fluid system also monitors the condition of the seals. High leakage from the seals will be detected, setting off alarms and trips. The barrier fluid is usually a water-glycol mixture.

The seal materials selected are carbon on the flexible static seal and silicon carbide on the dynamic seal half. Between the mechanical seal and the gearbox, a chamber drained to atmospheric pressure ensures that no water or barrier fluid

enters the gearbox, even if one of the seals should fail. It also drains the small amount of barrier fluid leakage. The chamber is sealed by a labyrinth seal against the gearbox side.

Lube oil system

In accordance with our philosophy of a compact water injection pump, the combined lube system serves the pump and gear units and is integrated into the pump skid.

The integrated design eliminates lube oil return piping from the pump bearings and simplifies the total lube oil feed-piping and valves.

A benefit of this integration is that the pump skid can be made considerably smaller, adding to the reduction in weight of the unit.

The lube oil system comprises the pump and driver.

To give optimum lubrication conditions, the lube oil is continuously circulated and filtered at standby.

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