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ENGINEERING
TOMORROW

Danfoss

Making **fresh water** possible
in a **sustainable** and
energy-efficient way

High-pressure pumps for seawater reverse osmosis applications





Wherever people need to purify water for drinking, seawater reverse osmosis (SWRO) plays an increasingly important role. Danfoss High Pressure Pumps has a clear mission: develop and market the best possible high-pressure pumps and accessories to enable our customers to make clean water. Reliably, efficiently and sustainably.

Setting new standards for high-pressure pumps – at the heart of seawater RO applications

Fresh, clean water is vital to people everywhere. But access to drinkable water from municipal sources is often prohibitively expensive or simply not an option.

The solution? It is all around us. Brackish water and seawater are abundant, cheap and renewable. But they need to be purified to make drinkable water.

Danfoss Axial Piston Principle (APP) high-pressure pumps are at the heart of more and more small and medium-sized seawater RO applications – because they provide high-pressure reliably and inexpensively.

- 70% of Earth is covered with water
- 97% of this water is seawater
- Only 1% of Earth's water is drinkable
- Worldwide consumption of drinking water doubles every 20 years

Clean water via Reverse Osmosis

Reverse osmosis (ww) has emerged as a preferred method for purifying brackish water and seawater. The process is simple and compact – and requires less energy than other desalination techniques.

While RO is used in massive plants capable of supplying major cities with fresh water, it is also the ideal water purification technique for a host of smaller applications in hotels and resorts, aboard ships and on offshore installations.

The heart of seawater RO systems: Rugged APP high-pressure pumps

Danfoss high-pressure pumps set new standards for small and medium-sized seawater RO applications ranging up to 92 m³/h (405 gpm).

Our dedicated high-pressure pumps build on decades of experience in developing pumps for other critical applications. Small in size and unsurpassed in engineering quality, the Danfoss range of high-pressure pumps are at the heart of more than 20,000 seawater RO systems throughout the world.

Cost-efficient Danfoss APP high-pressure pumps function both as main pumps and as reversing pumps (motors) for energy recovery in seawater RO applications.

Dedicated seawater RO pump expertise from a world leader

Danfoss High Pressure Pumps is a division of the Danfoss Group. We and our customers benefit from our close connection to a world leader in development and production of a wide range of mechanical and electronic products and controls. We draw on the extensive Danfoss R&D resources and quality systems, as well as the Group's worldwide manufacturing, distribution and service networks.

We work hard for our growing group of OEM and consulting engineer customers, beginning with extensive pre-sale consultation to determine the right solution for a wide range of seawater RO challenges – and continuing through delivery and uncompromising after-sales support.

APP pump advantages

| | | | | Small SWRO up to 600 CMD | | Midsize SWRO 600-2,000 CMD | |
|------------------|----------------------|------------|----------------|-----------------------------------|---------------------|-----------------------------------|---------------------|
| | Time between service | Efficiency | Flow pulsation | Specific energy with isobaric ERD | TCO 2 years (Index) | Specific energy with isobaric ERD | TCO 2 years (Index) |
| APP pump | 8,000 hrs. | Up to 92% | <1.5% | 2.3 kW/m ³ | 100 | 2.2 kW/m ³ | 100 |
| Plunger pump | 1,000-3,000 hrs. | 80-88% | 15.0% | 2.4 kW/m ³ | 130-160 | | |
| Centrifugal pump | | 55-76% | <1.0% | 3.0 kW/m ³ | 125-130 | 2.6 kW/m ³ | 115-130 |

Danfoss APP pumps outperform other pump types

Around the world, Danfoss High Pressure Pumps provide OEMs and consulting engineers with an extensive range of high-pressure APP pumps for seawater RO applications.

All pump parts are made of non-corrosive materials, e.g. Duplex and Super-Duplex stainless steel and carbon-reinforced PEEK.



Flexible and versatile

- The most compact high-pressure pump on the market, with more power per kilo than any other pump
- More design options than with any other RO pump: no need for frames, belt drives or gear boxes – APP pumps can be installed horizontally or vertically
- Wide flow range, with one APP pump covering the range of several centrifugal pumps
- Constant flow regardless of pressure variations

Low maintenance

- Self-lubricating design – no need for oil lubricants, ever
 - The pump's only seal is on the mechanical shaft
 - All pump parts are made of stainless steel (Duplex or Super Duplex) or polymer
- 8,000 hours maintenance free operation*

Low total costs of ownership

- Ultra-low energy consumption
- Market-leading efficiency: up to 92%
- Permeate cost, with energy recovery, can be reduced to below 2 kWh/m³
- Worldwide support, stock and service networks

* Danfoss guarantees a minimum of 8,000 hours of operation (maximum 18 months from date of production) provided that the pump is used according to Danfoss specifications for pre-filtration, pressure, and rotation speed. Please consult Danfoss High Pressure Pumps for further information.

High-pressure pumps from Danfoss: The right choice wherever fresh water matters



LAND BASED

Land based applications

APP high-pressure pumps from Danfoss keep fresh water flowing at hotels, resorts and other installations in coastal regions around the world. APP pumps are suitable for both brackish water (5,000-20,000 ppm/mg/l) and seawater (20,000-50,000 ppm/mg/l).

- Extremely low energy consumption, with up to 92% efficiency
- Whisper quiet: Danfoss high-pressure pumps are among the most silent in the industry
- Ultra-low maintenance reduces service costs

Pump retrofit cuts energy and maintenance costs at resort

The Challenge: Shangri-La's Mactan Resort and Spa, located on Cebu Island, is the Philippines' premier five-star resort, requiring 1,000 m³ of fresh water per day for its 547 rooms, 7 restaurants and bars, massive pools and spa. When the lush seaside retreat needed to retrofit its old seawater plant, management's main objectives were to reduce energy costs and minimize maintenance.

The Solution: The Danfoss APP 21 pump was chosen as the plant workhorse, along with an energy recovery device. Energy consumption was reduced by an impressive 1.7 kWh/m³, which corresponds to yearly savings of € 62,050. Since the self-lubricating

APP 21 requires no preventive care, maintenance was reduced to a minimum. As an added bonus, noise pollution from the old pump was so radically reduced that the plant is now virtually inaudible from all floors – so guests at Shangri-La's Mactan Resort and Spa can relax more than ever.



MARINE & OFFSHORE

Marine and offshore applications

Whether on offshore rigs or aboard private yachts and commercial ships, Danfoss seawater APP pumps are at the heart of seawater RO systems across the seven seas. We have extensive experience in working with OEMs to provide dedicated solutions for small and medium-size applications at sea.

The Royal Navy converts aircraft carrier from flash distillation to RO

The Challenge: HMS Ark Royal is the Royal Navy's largest Invincible-class light aircraft carrier, with a crew of 685 and a Fleet Air Arm of 366. The ship was originally fitted with flash distillers to purify water, but their high energy

and maintenance costs led to a conversion to seawater RO in 2005-2006. Salt Separation Services Ltd., who built the new RO plants, wanted to find the right high-pressure pumps for the job.

The solution: Danfoss APP pumps were selected due to their high reliability, low maintenance and small footprint – and are now at the heart of no less than five seawater RO plants aboard HMS Ark Royal: 1 × 150 m³/day, 2 × 100 m³/day, and 2 × 5 m³/day. On the three larger plants, the compact pumps are built into shock-mounted skids so they can easily be routed into position.



- Simple to operate
- Minimal maintenance, long service intervals
- Small but effective
- Compact, light in weight



Mobile and containerized applications

Climate change, natural disasters and humanitarian relief projects often mean that clean drinking water can suddenly become a precious commodity that saves lives. Danfoss APP pumps are particularly well suited for small and large-scale mobile applications due to the compact design which is the smallest in the RO market, as well as the extremely high efficiency.



Wind-driven RO system tested by Dutch university

The challenge: Delft University of Technology wanted to harness a traditional agricultural windmill to drive a RO plant capable of providing fresh water to a village of 500 inhabitants. Despite the need for high-pressure pumping, no electricity would be available to power the pump.

The solution: Researchers chose Danfoss SWPE 1.5-1.2 due to the exceptional energy efficiency of the APP pump and APM energy recovery. But it was the pump's long maintenance-free operation that was particularly appealing for use in remote areas. After successful testing in the Netherlands, the unit was moved to Curacao for operation. The plant is expected to produce 5 m³ of fresh water per day.

- Small footprint, vertical or horizontal orientation, no belt drive: easy to fit into tight spaces
- No need for oil lubrication, ever. 8,000 hours maintenance-free operation
- Low vibration means low noise; light in weight
- All pumps can be delivered according to ATEX
- Approved for NATO (N-cage) and specified by military organizations around the world
- Pumps can be made according to API 674 and NORSOK M-650

An extensive range of high-pressure pumps and accessories to power seawater RO applications



APP high-pressure pumps

Applications: APP pumps are designed to supply low viscosity and corrosive fluids under high pressure, e.g. in seawater RO applications.

Design: APP pumps are based on the Axial Piston Principle, enabling a very light and compact design. Lubrication of the moving parts in the pumps is provided by the fluid itself, eliminating any need for additional lubrication.

APP pumps are fixed displacement pumps with constant flow, since flow is proportional to input shaft revolutions and pump displacement.

Materials: All pump parts are made of non-corrosive materials, e.g. Duplex and Super Duplex stainless steel and carbon-reinforced PEEK.

| APP pumps | | | | | | |
|-----------|-------|----------------|------------|---|-----------------------|----------------|
| Pump type | Flow | | | Energy consumption @ 80 barg (1,160 psig) | | Pump speed |
| | rpm | Metric measure | US measure | Metric measure | US measure | Metric measure |
| APP 0.6 | 3,000 | 0.7 m³/h | 2.8 gpm | 1.7 kW | 2.3 HP | 700-3,450 rpm |
| APP 0.8 | 3,000 | 0.9 m³/h | 3.8 gpm | 2.2 kW | 3.0 HP | 700-3,450 rpm |
| APP 1.0 | 3,000 | 1.0 m³/h | 4.6 gpm | 2.6 kW | 3.5 HP | 700-3,450 rpm |
| APP 1.5 | 3,000 | 1.6 m³/h | 6.9 gpm | 3.9 kW | 5.4 HP | 700-3,450 rpm |
| APP 1.8 | 3,000 | 1.7 m³/h | 7.4 gpm | 4.2 kW | 5.8 HP | 700-3,450 rpm |
| APP 2.2 | 3,000 | 2.2 m³/h | 9.7 gpm | 5.2 kW | 7.1 HP | 700-3,450 rpm |
| APP 2.5 | 3,000 | 2.6 m³/h | 11.5 gpm | 6.5 kW | 8.3 HP | 700-3,000 rpm |
| APP 3.0 | 3,000 | 3.0 m³/h | 13.1 gpm | 7.4 kW | 10.0 HP | 700-3,450 rpm |
| APP 3.5 | 3,000 | 3.5 m³/h | 15.3 gpm | 8.7 kW | 11.8 HP | 700-3,000 rpm |
| APP 5.1 | 1,800 | 5.0 m³/h | 22.0 gpm | 12.9 kW | 17.3 HP | 700-1,800 rpm |
| APP 6.5 | 1,800 | 6.4 m³/h | 28.2 gpm | 16.3 kW | 21.9 HP | 700-1,800 rpm |
| APP 7.2 | 1,800 | 7.2 m³/h | 31.7 gpm | 18.0 kW | 24.2 HP | 700-1,800 rpm |
| APP 8.2 | 1,800 | 8.2 m³/h | 35.9 gpm | 20.7 kW | 27.8 HP | 700-1,800 rpm |
| APP 10.2 | 1,800 | 10.4 m³/h | 45.8 gpm | 25.8 kW | 34.6 HP | 700-1,800 rpm |
| APP 11 | 1,200 | 11.0 m³/h | 48.5 gpm | 27.8 kW | 37.3 HP | 700-1,200 rpm |
| APP 11 | 1,500 | 11.2 m³/h | 49.3 gpm | 25.5 kW (70 barg) | 34.2 HP (1,015 psig) | 700-1,500 rpm |
| APP 13 | 1,200 | 13.4 m³/h | 58.9 gpm | 33.7 kW | 45.2 HP | 700-1,200 rpm |
| APP 13 | 1,500 | 13.8 m³/h | 60.7 gpm | 30.9 kW (70 barg) | 41.4 HP (1,015 psig) | 700-1,500 rpm |
| APP 16 | 1,200 | 16.0 m³/h | 70.7 gpm | 38.5kW | 51.7 HP | 700-1,200 rpm |
| APP 16 | 1,500 | 16.0 m³/h | 70.7 gpm | 34.0 kW (70 barg) | 45.6 HP (1,015 psig) | 700-1,500 rpm |
| APP 17 | 1,200 | 17.5 m³/h | 77.0 gpm | 41.7 kW | 55.9 HP | 700-1,200 rpm |
| APP 17 | 1,500 | 16.9 m³/h | 74.4 gpm | 35.9 kW (70 barg) | 48.2 HP (1,015 psig)) | 700-1,500 rpm |
| APP 19 | 1,200 | 18.8 m³/h | 82.9 gpm | 45.9 kW | 61.6 HP | 700-1,200 rpm |
| APP 19 | 1,500 | 18.8 m³/h | 82.9 gpm | 40.1 kW (70 barg) | 53.8 HP (1,015 psig) | 700-1,500 rpm |
| APP 22 | 1,200 | 21.5 m³/h | 94.5 gpm | 51.2 kW | 68.7 HP | 700-1,200 rpm |
| APP 22 | 1,500 | 21.8 m³/h | 95.9 gpm | 46.6 kW (70 barg) | 62.5 HP (1,015 psig) | 700-1,500 rpm |

APP pumps

| Pump type | CFlow | | | Energy consumption @ 80 barg (1,160 psig) | | Pump speed |
|-----------|-------|------------------------|------------|---|-----------------------|----------------|
| | rpm | Metric measure | US measure | Metric measure | US measure | Metric measure |
| APP 21 | 1,200 | 21.3 m ³ /h | 93.7 gpm | 51.0 kW | 68.4 HP | 700-1,200 rpm |
| APP 21 | 1,500 | 22.2 m ³ /h | 97.7 gpm | 54.3 kW | 72.8 HP | 700-1,500 rpm |
| APP 24 | 1,200 | 25.2 m ³ /h | 110.9 gpm | 59.9 kW | 80.3 HP | 700-1,200 rpm |
| APP 24 | 1,500 | 24.5 m ³ /h | 106.2 gpm | 59.3 kW | 79.5 HP | 700-1,500 rpm |
| APP 26 | 1,200 | 26.9 m ³ /h | 118.4 gpm | 64.1 kW | 86.0 HP | 700-1,200 rpm |
| APP 26 | 1,500 | 26.7 m ³ /h | 117.4 gpm | 65.1 kW | 87.4 HP | 700-1,500 rpm |
| APP 30 | 1,200 | 31.2 m ³ /h | 137.3 gpm | 74.3 kW | 99.7 HP | 700-1,200 rpm |
| APP 30 | 1,500 | 31.3 m ³ /h | 137.7 gpm | 75.4 kW | 101.0 HP | 700-1,500 rpm |
| APP 38 | 1,500 | 38.4 m ³ /h | 168.9 gpm | 92.3 kW | 123.7 HP | 700-1,500 rpm |
| APP 46 | 1,780 | 46.0 m ³ /h | 203.0 gpm | 96.6 kW (70 barg) | 130.0 HP (1,015 psig) | 700-1,780 rpm |
| APP 53 | 1,500 | 53.0 m ³ /h | 235.0 gpm | 130.0 kW | 174.0 HP | 700-1,500 rpm |
| APP 65 | 1,500 | 67.0 m ³ /h | 295.0 gpm | 166.0 kW | 223.0 HP | 700-1,500 rpm |
| APP 78 | 1,500 | 78.0 m ³ /h | 345.0 gpm | 188.0 kW | 252.0 HP | 700-1,500 rpm |
| APP 86 | 1,700 | 88.0 m ³ /h | 387.0 gpm | 185.0 kW (70 barg) | 248.0 HP (1,105 psig) | 700-1,700 rpm |
| APP 92 | 1,780 | 92.0 m ³ /h | 405.0 gpm | 196.0 kW (70 barg) | 263.0 HP (1,015 psig) | 700-1,780 rpm |

Non-return valves with Vic. ends

Applications: Allow flow in one direction while blocking it in the other.

Design: Conical poppet design, which ensures sealing when used with a low viscosity medium such as seawater.

Capacity: Wide flow range that fits to our pump range.



Danfoss High Pressure Pumps supplies a line of non-return valves, Vic. hose connectors, high-pressure hoses, hose tails and Vic. clamps in Duplex.

Filter housings and cartridges

It is recommended to use filters from the Danfoss filter product range.



A wide range of filter housings and cartridges for pre-filtration is available.

Energy Recovery Devices (iSave)

Application: The iSave is a high efficient energy recovery device that captures wasted pressure from the membrane reject flow and transfers it directly to the membrane feed flow.

Design: iSave unit combines a rotary pressure exchanger, a high-pressure positive displacement booster pump and an electric motor.

Capacity: The iSaves are available in sizes from 6-70 m³/h with efficiency rates up to 92%.



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High-pressure pumps and solutions from a **world leader**

Dedicated, committed and with a proven track record

Danfoss engineers technologies that enable the world of tomorrow to do more with less

Danfoss is a leading global player within the development and production of mechanical and electronic products and controls.

Since 1933, our extensive know-how has made modern life easier and we continue to break new ground in our core business areas.

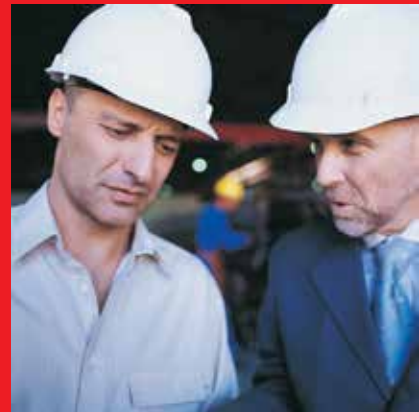
Every day, more than 250,000 items are produced at 63 factories in 19 countries. Impressive as these figures are, we are most proud of the way our dedicated employees apply the high-quality components in customer solutions, adding value to the end product. Danfoss employs more than 24,000 people world-wide.

Leading technology

Danfoss High Pressure Pumps division has pioneered the development of axial piston pumps for demanding hydraulics applications in a broad range of industries. Today, Danfoss is world leader in axial piston pump technology for pumps made of stainless steel and carbon-reinforced PEEK, bringing all the advantages of positive displacement pumps to applications that require liquid at high pressure.

Partner with us

Building strong partnerships with our customers is of great importance to us, because it is purely by understanding our customers' needs that we can meet the expectations of tomorrow. We look forward to doing business with you and building a strong relationship.



Let us help you optimise your RO project

Our dedicated team of seawater RO experts will be happy to provide design support, technical expertise and customer service. From our headquarters in Denmark or from our worldwide network of subsidiaries, distributors and agents – Danfoss High Pressure Pumps is as close as an e-mail or telephone call.

For more information, please visit hpp.danfoss.com or contact us in Denmark or at one of our regional offices.

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