

MAKING MODERN LIVING POSSIBLE

*Danfoss*



**Making fresh water possible**

RO SOLUTIONS

Wherever people need to purify water for drinking, seawater reverse osmosis (RO) plays an increasingly important role.

Danfoss RO Solutions 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 (RO) 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 from 0.6 to 38 m<sup>3</sup>/h (2.6 to 167 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 15,000 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 RO Solutions 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

|                  | Service Life      | Efficiency | Pressure Pulsation | Energy Consumption kWh/m <sup>3</sup> , feed flow. (APP = Index 100) | Total Cost of Ownership, 1 year APP=Index 100 |
|------------------|-------------------|------------|--------------------|----------------------------------------------------------------------|-----------------------------------------------|
| APP              | 8,000 hours       | > 90 %     | < 2 %              | 4.9 (100)                                                            | 100                                           |
| Plunger Pump     | 1,000 hours       | 80-85 %    | 15 %               | 5.3 (108)                                                            | 116                                           |
|                  | (Oil = 500 hours) |            |                    |                                                                      |                                               |
| Centrifugal Pump | 8,000 hours       | 50-70 %    | 0 %                | 7.82 (159)                                                           | 157                                           |

*Danfoss APP pumps outperform other pump types*

**Around the world, Danfoss RO Solutions 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

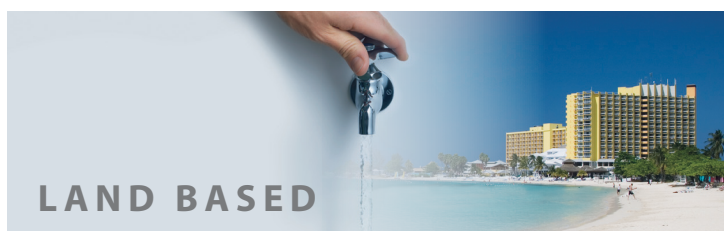
- Self-lubricating design – no need for oil lubricants, ever
  - The pump's only seal is on the mechanical shaft
  - All pump parts are made of stainless steel (Duplex or Super Duplex) or polymer
- 8,000 hours maintenance free operation\*

### Low total costs of ownership

- Ultra-low energy consumption
- Market-leading efficiency: up to 97 % (volumetric) and 93 % (mechanical)
- Permeate cost, with energy recovery, can be reduced to below 2 kWh/m<sup>3</sup>
- 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 RO Solutions for further information.

## High-pressure pumps from Danfoss RO Solutions: the right choice wherever fresh water matters



### Land based applications

APP high-pressure pumps from Danfoss RO Solutions 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 sea-water (20,000-50,000 ppm/mg/l).

- **Extremely low energy consumption, with up to 97% 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 m<sup>3</sup> 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 APP21 pump was chosen as the plant workhorse, along with an energy recovery device. Energy consumption was reduced by an impressive 1.7 kWh/m<sup>3</sup>, which corresponds to yearly savings of € 62,050. Since the self-lubricating APP21 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 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.



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**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:  $1 \times 150 \text{ m}^3/\text{day}$ ,  $2 \times 100 \text{ m}^3/\text{day}$ , and  $2 \times 5 \text{ m}^3/\text{day}$ . 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 life
- Small but effective; 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 RO 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.

- 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

## 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  $5 \text{ m}^3$  of fresh water per day.

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

Danfoss RO Solutions develops and markets an extensive range of high-pressure pumps and valves. Proven to work in extreme circumstances – and proven to work together.



### 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 bar (1160 psi) |            | Pump speed     |
|-----------|------|----------------|------------|----------------------------------------|------------|----------------|
|           | rpm  | Metric measure | US measure | Metric measure                         | US measure | Metric measure |
| APP 0.6   | 3000 | 0.6 m³/h       | 2.6 gpm    | 1.9 kW                                 | 2.5 HP     | 700-3450 rpm   |
| APP 0.8   | 3000 | 0.8 m³/h       | 3.5 gpm    | 2.5 kW                                 | 3.3 HP     | 700-3450 rpm   |
| APP 1.0   | 3000 | 1.0 m³/h       | 4.4 gpm    | 2.9 kW                                 | 3.9 HP     | 700-3450 rpm   |
| APP 1.5   | 3000 | 1.5 m³/h       | 6.6 gpm    | 4.5 kW                                 | 6.0 HP     | 700-3450 rpm   |
| APP 1.8   | 3000 | 1.7 m³/h       | 7.5 gpm    | 4.8 kW                                 | 6.4 HP     | 700-3450 rpm   |
| APP 2.2   | 3000 | 2.1 m³/h       | 9.2 gpm    | 6.0 kW                                 | 8.0 HP     | 700-3450 rpm   |
| APP 2.5   | 3000 | 2.6 m³/h       | 11.4 gpm   | 7.2 kW                                 | 9.6 HP     | 700-3000 rpm   |
| APP 3.0   | 3000 | 3.0 m³/h       | 13.2 gpm   | 8.0 kW                                 | 10.7 HP    | 700-3450 rpm   |
| APP 3.5   | 3000 | 3.5 m³/h       | 15.4 gpm   | 9.3 kW                                 | 12.5 HP    | 700-3000 rpm   |
| APP 5.1   | 1800 | 4.9 m³/h       | 21.6 gpm   | 13.7 kW                                | 18.4 HP    | 700-1800 rpm   |
| APP 6.5   | 1800 | 6.2 m³/h       | 27.3 gpm   | 17.3 kW                                | 23.2 HP    | 700-1800 rpm   |
| APP 7.2   | 1800 | 6.9 m³/h       | 30.4 gpm   | 19.2 kW                                | 25.7 HP    | 700-1800 rpm   |
| APP 8.2   | 1800 | 8.2 m³/h       | 36.1 gpm   | 21.7 kW                                | 29.1 HP    | 700-1800 rpm   |
| APP 10.2  | 1800 | 10.3 m³/h      | 45.3 gpm   | 27.7 kW                                | 37.1 HP    | 700-1800 rpm   |
| APP 11    | 1200 | 11.0 m³/h      | 48.4 gpm   | 30.6 kW                                | 41.0 HP    | 700-1200 rpm   |
| APP 11    | 1500 | 11.1 m³/h      | 48.9 gpm   | 31.6 kW                                | 42.3 HP    | 700-1500 rpm   |
| APP 13    | 1200 | 13.1 m³/h      | 57.7 gpm   | 36.3 kW                                | 48.6 HP    | 700-1200 rpm   |
| APP 13    | 1500 | 13.5 m³/h      | 59.4 gpm   | 38.3 kW                                | 51.3 HP    | 700-1500 rpm   |
| APP 16    | 1200 | 16.0 m³/h      | 70.4 gpm   | 43.0 kW                                | 58.0 HP    | 700-1200 rpm   |
| APP 16    | 1500 | 15.8 m³/h      | 69.6 gpm   | 36.0 kW (70 bar)                       | 48.0 HP    | 700-1500 rpm   |
| APP 17    | 1200 | 17.2 m³/h      | 75.7 gpm   | 46.0 kW                                | 62.0 HP    | 700-1200 rpm   |
| APP 17    | 1500 | 16.9 m³/h      | 74.4 gpm   | 38.0 kW (70 bar)                       | 51.0 HP    | 700-1500 rpm   |
| APP 19    | 1200 | 18.8 m³/h      | 82.8 gpm   | 50.0 kW                                | 67.0 HP    | 700-1200 rpm   |
| APP 19    | 1500 | 18.8 m³/h      | 82.8 gpm   | 43.0 kW (70 bar)                       | 58.0 HP    | 700-1500 rpm   |
| APP 22    | 1200 | 21.5 m³/h      | 94.7 gpm   | 57.0 kW                                | 76.0 HP    | 700-1200 rpm   |
| APP 22    | 1500 | 21.7 m³/h      | 95.5 gpm   | 50.0 kW (70 bar)                       | 67.0 HP    | 700-1500 rpm   |
| APP 21    | 1200 | 20.9 m³/h      | 92.0 gpm   | 55.0 kW                                | 73.7 HP    | 700-1200 rpm   |
| APP 21    | 1500 | 21.9 m³/h      | 96.4 gpm   | 58.0 kW                                | 77.8 HP    | 700-1500 rpm   |
| APP 24    | 1200 | 24.8 m³/h      | 109.1 gpm  | 65.0 kW                                | 87.1 HP    | 700-1200 rpm   |
| APP 24    | 1500 | 24.1 m³/h      | 106.1 gpm  | 65.0 kW                                | 87.1 HP    | 700-1500 rpm   |
| APP 26    | 1200 | 26.6 m³/h      | 117.0 gpm  | 69.0 kW                                | 92.5 HP    | 700-1200 rpm   |
| APP 26    | 1500 | 26.2 m³/h      | 115.4 gpm  | 69.0 kW                                | 92.5 HP    | 700-1500 rpm   |
| APP 30    | 1200 | 30.7 m³/h      | 135.1 gpm  | 78.0 kW                                | 104.5 HP   | 700-1200 rpm   |
| APP 30    | 1500 | 31.0 m³/h      | 136.5 gpm  | 80.0 kW                                | 107.0 HP   | 700-1500 rpm   |
| APP 38    | 1500 | 38.3 m³/h      | 168.6 gpm  | 101.0 kW                               | 135.3 HP   | 700-1500 rpm   |

### Sea water pump with energy recovery (SWPE)

Application: The SWPE is a high efficiency energy recovery unit for reverse osmosis filtration of sea water. Energy recovery is achieved by high-pressure brine from membranes being feed into the recovery device (APM) that converts the energy in the pressurized brine to mechanical energy for reuse by the electric motor.



Design: The SWPE energy recovery unit consists of an APP pump and an APM motor, both connected to a double-shafted electric motor.

The permeate flow and recovery rate depend on the difference between the size of an APP and an APM, as they have a fixed volumetric displacement.

Capacity: SWPE are available in sizes from 4-30 m<sup>3</sup>/day with recovery rates between 29%-32%. Other sizes are available upon request. Please contact your local Danfoss RO Solutions office.



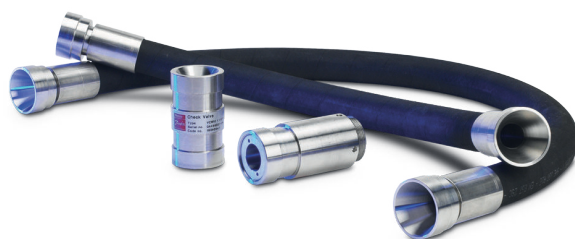
A wide range of filter housings and cartridges for pre-filtration is available.

### 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 RO Solutions supplies a line of non-return valves, Vic. hose connectors, high-pressure hoses, hose tails and Vic. clamps in Duplex.

### For more information

For more information on all Danfoss high-pressure pumps, valves and other accessories (including frequency converters, soft starters, high and low-pressure hoses, connections, coupling kits, electrical motors, filters etc.), please visit [www.ro-solutions.com](http://www.ro-solutions.com).

- Complete data sheets
- Users' guides & instructions
- References
- Regional sales offices

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

Danfoss A/S is one of the largest industrial companies in Denmark, with net sales of DKK 33 billion (EUR 4.4 billion). We employ more than 33,000 people, 6,300 of whom work at 15 locations across Denmark.

Danfoss is an international group and a leader in research, development and production for a wide spectrum of different industries.

Danfoss A/S is represented with 61 factories in 25 countries.

The Group's primary aim is to create quality of life for our stakeholders and to be a leader in refrigeration, heating and motion controls.

Our work is based on our core values: Trust, Passion for Technology, Reliability, Global Perspective with Local Commitment, and Environmental and Social Responsibility.



### 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 RO Solutions is as close as an e-mail or telephone call.

For more information, please visit [www.ro-solutions.com](http://www.ro-solutions.com) or contact us in Denmark or at one of our regional offices.