Seal-less Pump Technology

Reverse Osmosis, Nano Filtration and Ultra Filtration

Simplicity - Reliability
Hydra-Cell® Reverse Osmosis Pumps – High reliability,

Hydra-Cell® pumps are used in a wide variety of applications.

- Mobile drinking water unit
- Sea and high brackish water desalination
- Offshore and shipboard desalination
- Pharmaceutical, and laboratory process water purification

- Reverse Osmosis
compact, seal-less and energy efficient design

Food and beverage concentration and process water purification

Remote solar powered drinking water production

Chemical and pharmaceutical plant waste stream reduction and salt solution concentration

• Nano Filtration • Ultra Filtration
Hydra-Cell® Reverse Osmosis Pumps

Seal-less pumps for long life, high reliability and low total life-cycle costs

High efficiency, high pressure pumps for seawater and high brackish water desalination, process water conditioning and purification, waste water reduction, solvent/acid recovery and solute concentration.

• Reverse Osmosis  • Nano Filtration  • Ultra Filtration

<table>
<thead>
<tr>
<th>Typical Liquids Pumped</th>
<th>Challenges in Pumping</th>
<th>The Hydra-Cell® Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals...</td>
<td>• Potentially corrosive</td>
<td>• Corrosion resistant liquid head materials available</td>
</tr>
<tr>
<td>acids, salt solutions and proprietary chemicals</td>
<td>• Leaks can be harmful</td>
<td>• 100% Sealed unit prevents leaks</td>
</tr>
<tr>
<td>Beverages, Juices and Foodstuffs...</td>
<td>• Solids may crystallise and cause wear</td>
<td>• Seal-less design can pump solids up to 500 µm dia.</td>
</tr>
<tr>
<td>for concentration</td>
<td>• May contain difficult to pump solids that can be abrasive</td>
<td>• Seal-less pump chamber for high reliability</td>
</tr>
<tr>
<td></td>
<td>• Potentially corrosive</td>
<td></td>
</tr>
<tr>
<td>Brakish Water...</td>
<td>• Solid particles may be present from poorly attended pre-filtration</td>
<td>• Seal-less design can pump solids up to 500 µm dia.</td>
</tr>
<tr>
<td>18 – 25k TDS</td>
<td>• Remote units may run dry</td>
<td>• Run-dry indefinitely</td>
</tr>
<tr>
<td>Typical Liquids Pumped</td>
<td>Challenges in Pumping</td>
<td>The Hydra-Cell® Advantage</td>
</tr>
<tr>
<td>------------------------</td>
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</tr>
</tbody>
</table>
| Seawater…              | **Corrosive. Corrosion increases with increase in salt content**  
                         | **Salt crystallization can occur on internal surfaces when pump is not in operation. Crystallised solids can cause premature wear of dynamic seals or tight tolerances**  
                         | **Non-lubricating**  
                         | **Raw feed water contains solids which may get through pre-filtration, causing problems with pumps with dynamic seals and tight tolerances in the pumped liquid**  
                         | **Poorly maintained pre-filtration can cause high pressure pumps to run dry**  
                         | **Corrosion resistant liquid head materials available**  
                         | **No tight tolerances to be damaged by salt crystals**  
                         | **No dynamic seals to wear**  
                         | **No need for lubrication from pumped liquid** |
| Waste Solvent Streams... | **May be corrosive and non-lubricating**  
                          | **Corrosion resistant liquid head materials available**  
                          | **No need for lubrication from pumped liquid** |
| Waste Water Streams…   | **Undissolved solids can be abrasive / non-lubricating / aggressive**  
                          | **Seal-less design can pump solids up to 1.5mm dia.** |
| from food and beverage process |                       |                                                  |
Hydra-Cell® advantages

Designed for 24/7 continuous use, Hydra-Cell® Seal-less Pumps are robust, reliable, efficient and highly tolerant of operator error.

These positive displacement pumps are used extensively in a wide variety of reverse osmosis applications where their high reliability, high efficiency and outstanding controllability are valued greatly.

High Reliability... low maintenance
Having No Dynamic Seals means high reliability.
- Runs dry indefinitely
- No seals to wear and leak
- No tight tolerances that could be susceptible to corrosion or damaged by particles
- Pumps liquids with viscosities from 0.01 to 6000 cSt
- Pumps liquids with up to 1.5mm dia. particulate matter
- No ‘drop off’ in performance due to seal wear

High efficiencies
- A true positive-displacement pump, Hydra-Cell® is one of the most efficient RO pumps available in the market

Reduced power usage and cost.

<table>
<thead>
<tr>
<th>Pump Flow rate m/hr</th>
<th>Discharge Pressure (bar)</th>
<th>Pump Power use (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>80</td>
<td>19.2</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>9.5</td>
</tr>
<tr>
<td>1.5</td>
<td>80</td>
<td>4.1</td>
</tr>
<tr>
<td>1.0</td>
<td>80</td>
<td>2.74</td>
</tr>
</tbody>
</table>

Constant flow rate... independent of pressure
- An increase in salt concentration results in an increase in osmotic pressure. Hydra-Cell®’s controllable flow rate means that efficiencies and yields can be maintained if feed water TDS increases, especially important in bore hole applications

Wide range of operating pressures

<table>
<thead>
<tr>
<th>Discharge Pressure Range</th>
<th>Inlet Pressure Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>0 bar</td>
<td>70, 80 or 172 bar (Model dependent)</td>
</tr>
</tbody>
</table>

With ERI - energy recovery device

<table>
<thead>
<tr>
<th>G25 + PX</th>
<th>G35 + PX</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 30S ERI</td>
<td>- 70S ERI</td>
</tr>
<tr>
<td>10.4</td>
<td>18.2</td>
</tr>
<tr>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>11.8</td>
<td>22.3</td>
</tr>
</tbody>
</table>
Ultimate controllability

- Hydra-Cell® Pumps exhibit a linear relationship between pump shaft speed and flow rate better than +/- 3%.
- The speed of the pump can be adjusted from 10 rpm to 1500 rpm (or 1000 rpm depending on model) for accurate flow control.

Energy saving

- Very economical to run compared with centrifugal pumps.
- Smaller, more compact motors required.

Compared with multi-stage centrifugal pumping water at 20 bar:

<table>
<thead>
<tr>
<th>Flow (m³/hr)</th>
<th>Energy used (kw)</th>
<th>Energy saving</th>
<th>Potential annual euro saving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Centrifugal</td>
<td>Hydra-Cell</td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>1.54</td>
<td>0.5</td>
<td>67% €945</td>
</tr>
<tr>
<td>1.5</td>
<td>2.0</td>
<td>1.44</td>
<td>28% €470</td>
</tr>
</tbody>
</table>

Compared with multi-stage centrifugal pumping water at 40 bar:

<table>
<thead>
<tr>
<th>Flow (m³/hr)</th>
<th>Energy used (kw)</th>
<th>Energy saving</th>
<th>Potential annual euro saving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Centrifugal</td>
<td>Hydra-Cell</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>9.34</td>
<td>6.1</td>
<td>35% €2,830</td>
</tr>
<tr>
<td>7.6</td>
<td>15.4</td>
<td>11.0</td>
<td>28% €3,840</td>
</tr>
</tbody>
</table>

Simple robust design

- Designed and built for long service life.
- Simple maintenance with no special tool requirements.
- No critical tolerances to be aware of during maintenance.
- In-situ repair possibilities... no costly removal and transportation to workshops or special clean environment.

Membrane flushing

- Forward flushing and chemical treatment are made easier because the chemicals can readily pass through a Hydra-Cell® pump at a pressure of 2 bar, removing the need for extra pump bypass pipe work and control valves.

Energy recovery compatible

- Suitable for use with pressure exchanger, energy recovery technology.

Minimal filtration to protect the pump

- No mechanical seals or tight tolerances that need protection by fine filtration. 300µm filtration is sufficient. (Some pumping technologies, such as axial piston pumps may need costly 5µm absolute filters for protection. These blind easily and may need replacing after 15 – 20 days use.)
- The level of filtration can be determined by what the membrane needs and not the needs of the high pressure pump, saving operating costs.

Cement plant – RO treatment of high TDS ground water for use in process.
# Hydra-Cell® Performance Advantages

## Reciprocating Plunger Pumps
- Have dynamic seals that are design to leak to lubricate the pistons and plungers
- Requires careful operational monitoring so filters do not blind and cause damage
- Valve closure by operator leading to liquid starvation, will cause immediate damage to the pump

## Axial Piston Plunger Pump
- Requires a pressure feed to maintain the hydrodynamic film between the piston foot and swash plate
- Requires careful operational monitoring so filters do not blind and cause damage
- Tight manufacturing tolerances can be degraded by the smallest of particles (5 micron absolute filters are often recommended (Cost $500))
- Maintenance requires a clean environment to ensure the integrity of the tight tolerances
- Maximum inlet pressure of 5 bar

## Multistage Centrifugal Pumps
- Large footprint required to achieve high pressure
- Mechanical seals and packing require adjustment, maintenance or replacement
- Requires carefully balancing to reduce levels of vibration, seal failure and premature wear
- Efficiency quickly reduces when pump is operated away from its best efficiency point (Discharge pressure / fluctuations, Impellor or Seal wear)

## Hydraul-Cell® Advantages
- The seal-less design of the Hydra-Cell® eliminates the requirement of pressure feed, saving costs
- 200 micron filtration is adequate to protect the pumps
- Hydra-Cell® can pump liquids with particles
- Hydra-Cell® offer simple design and maintenance of the liquid end and can often be done in-situ
- Hydra-Cell can handle up to 34 bar

- Hydra-Cell® can meet these same flows and pressures with a much smaller footprint, saving space and costs
- The seal-less design of Hydra-Cell® means that there are no seals or packing to maintain or replace
- Hydra-Cell® can be easily maintained in-situ
- Highly efficiency give significant energy savings

- The seal-less design of Hydra-Cell® mean that the pumped liquid and lubricating liquid are kept completely separate
- Hydra-Cell® pumps do not require filtration
- Hydra-Cell®’s Kel-Cell technology protects the pump, allowing the operator to rectify the error without causing damage.
Hydra-Cell® Principles of Operation - Wobble Plate

**Wobble Plate Models**

1. Drive Shaft
2. Tapered Roller Bearings
3. Fixed-angle Cam/Wobble Plate
4. Hydraulic Cells (Patented)
5. Diaphragms
6. Inlet Valve Assembly
7. Discharge Valve Assembly
8. C62 Pressure Regulating Valve

**Reliable, Efficient Pumping Action**

The drive shaft (1) is rigidly held in the pump housing by a large tapered roller bearing (2) at the rear of the shaft and a smaller bearing at the front of the shaft. Set between another pair of large bearings is a fixed-angle cam or Wobble Plate (3).

As the drive shaft turns, the swash plate moves, oscillating forward and back (converting axial motion into linear motion). The complete pumping mechanism is submerged in a lubricating oil bath.

The hydraulic cell (4) is moved sequentially by the Wobble plate and filled with oil on their rearward stroke. A ball check valve in the bottom of the piston ensures that the cell remains full of oil on its forward stroke.

The oil held in the Hydra-Cell balances the back side of the diaphragms (5) and causes the diaphragms to flex forward and back as the Wobble plate moves. This provides the pumping action.

To provide long trouble-free diaphragm life, Hydra-Cell hydraulically balances the diaphragm over the complete pressure range of the pump. The diaphragm faces only a 0.21 bar pressure differential regardless of the pressure at which liquid is being delivered - up to 172 bar on standard Hydra-Cell models and Hydra-Cell metering pumps.

Hydra-Cell Wobble plate pumps can have up to five diaphragms, and each diaphragm has its own pumping chamber that contains an inlet and discharge self-aligning horizontal disk check valve assembly (6). As the diaphragms move back, liquid enters the pump through a common inlet and passes through one of the inlet check valves. On the forward stroke, the diaphragm forces the liquid out the discharge check valve (7) and through the manifold common outlet. Equally spaced from one another, the diaphragms operate sequentially to provide consistent, low-pulse flow.

A Hydra-Cell C62 pressure regulating valve (8) is typically installed on the discharge side of the pump to regulate the pressure of downstream process or equipment.
**Liquid Head Materials**

For brackish or seawater applications the choice of liquid head material will depend on the level of dissolved solids (TDS).

<table>
<thead>
<tr>
<th>TDS Level</th>
<th>Liquid End Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15,000 ppm</td>
<td>Brass</td>
</tr>
<tr>
<td>&lt;25,000 ppm</td>
<td>316 Stainless Steel</td>
</tr>
<tr>
<td>&gt;25,000 ppm</td>
<td>Duplex Stainless Steel</td>
</tr>
</tbody>
</table>

For RO systems that are used to treat chemical waste streams, a wide range of materials is available, including:

- Hastelloy® CW12MW
- Duplex Alloy 2205
- Super Duplex Alloy 2507
- 316L Stainless Steel
- Brass
- Cast Iron
- Polypropylene
- PVDF (Kynar®)

**Diaphragm Materials**

A variety of materials is available to suit varying performance conditions, including:

- EPDM
- FKM
- PTFE
- Neoprene
- Buna
- Aflas®

**Treated Internal Surfaces**

- Internal surfaces in contact with the liquid can be polished to the following specifications:
  - 0.8 Ra
  - 0.4 Ra
- Stainless Steel internal surfaces in contact with the liquid can be supplied passivated.

**Pipe Connections**

Simple threaded connections.

Flanged connections.

Specialised flange connections e.g. Tri-Clamp® for pharmaceutical and food applications.
Hydra-Cell® Flow Capacities and Pressure Ratings

G Series and T Series Seal-less Pumps

The graph above displays the maximum flow capacity at a given pressure for each model series. The table below lists the maximum flow capacity and maximum pressure capability of each model series.

Please Note: Some models do not achieve maximum flow at maximum pressure. Refer to the individual model specifications in this section for precise flow and pressure capabilities by specific pump configuration.

<table>
<thead>
<tr>
<th>Model</th>
<th>Maximum Capacity l/min</th>
<th>Maximum Discharge Pressure bar</th>
<th>Maximum Operating Temperature °C</th>
<th>Maximum Inlet Pressure bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Non-Metallic</td>
<td>Metallic</td>
<td>Non-Metallic</td>
</tr>
<tr>
<td>G20</td>
<td>3.8</td>
<td>24</td>
<td>103</td>
<td>60°</td>
</tr>
<tr>
<td>G03</td>
<td>11.7</td>
<td>24</td>
<td>103</td>
<td>60°</td>
</tr>
<tr>
<td>G04</td>
<td>11.2</td>
<td>N/A</td>
<td>172</td>
<td>N/A</td>
</tr>
<tr>
<td>G10</td>
<td>33.4</td>
<td>24</td>
<td>103</td>
<td>60°</td>
</tr>
<tr>
<td>G12</td>
<td>33.4</td>
<td>N/A</td>
<td>172</td>
<td>N/A</td>
</tr>
<tr>
<td>G15/17</td>
<td>58.7</td>
<td>N/A</td>
<td>172</td>
<td>N/A</td>
</tr>
<tr>
<td>G25</td>
<td>75.9</td>
<td>24</td>
<td>69</td>
<td>60°</td>
</tr>
<tr>
<td>G35</td>
<td>138</td>
<td>N/A</td>
<td>103</td>
<td>N/A</td>
</tr>
<tr>
<td>T8045</td>
<td>170.4</td>
<td>N/A</td>
<td>207</td>
<td>N/A</td>
</tr>
<tr>
<td>T8030</td>
<td>98.4</td>
<td>N/A</td>
<td>345</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1 24 bar maximum with PVDF (Kynar®) liquid end; 17 bar maximum with Polypropylene liquid end.
2 Consult factory for correct component selection for temperatures from 160°F (71°C) to 250°F (121°C).
Hydra-Cell® + ERI PX® Energy Recovery Device

At 35% Recovery

At 40% Recovery

*PX Pressure Exchanger, PX and Pressure Exchanger are registered trademarks of Energy Recovery Inc.*