Radial piston pumps

1. General

Hydraulic pumps apply the displacement principle for converting mechanical into hydrostatic energy (DIN ISO 1219-1). The pumps described in this pamphlet are constant delivery pumps.

- Application
  These pumps serve generally to supply pressurized fluid to hydraulic consumers in hydraulic systems. The maximum permissible drive power is 30 kW, depending on size.

- Basic types (bearing design)
  R - Traditional version, where the eccentric is a roller bearing, suited even for very low speed ratings
  RG - New version, where the eccentric is a slide bearing, suited for fluids with bad lubrication characteristic (e.g. HFC) but not for low revolution ratings as this would prevent the generation of the necessary lubricating film.

- Mechanical design
  Radial piston pumps are valve controlled with cylinders in a radial arrangement. The cylinder radials in one, two or several superimposed layers (stars) are driven by bearings fitted eccentrically on the drive shaft (piston pressure stroke), then being returned to their idle position by springs (piston intake stroke). The fluid being delivered by the various cylinders is collected via manifolds feeding one joint pressure port. The pump housing shells are load-bearing elements supporting the cylinders and shaft bearings. The pumps run very smoothly as the drive shaft is statically balanced via counter weights. With the exception of the single- and double-cylinder pumps, there is always an uneven number of pistons per cylinder radial, which minimizes any pulse effect on the pump delivery.

- Design

**Motor pumps and hydraulic power packs type R and RG**

<table>
<thead>
<tr>
<th>Design</th>
<th>D 6010 H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic power packs type R and RG with several pressure outlets</td>
<td>D 6010 D</td>
</tr>
<tr>
<td>Radial piston pumps type R and RG with one main and one or two auxiliary outlets</td>
<td>D 6010 S</td>
</tr>
<tr>
<td>Hydraulic power packs type R and RG with DC-drive motor</td>
<td>D 6010 HDC</td>
</tr>
<tr>
<td>Radial piston pumps type R and RG with several pressure outlets</td>
<td>D 6010 DB</td>
</tr>
</tbody>
</table>

Cut-away demonstrator of double radial pump (Design 6012)

1. Pump cylinder, existing:
   1a) Cylinder
   1b) Piston
   1c) Return spring for the intake stroke
   1d) Integrated suction valve
   1e) Integrated pressure valve
   1f) Strainer holds back coarse contamination

2. Rear and front eccentric bearing for the pressure stroke

3. Manifold

4. Pressure outlet (pressure port)

5. Suction port

6. Drive shaft

7. Rear and front shaft bearing

8. Shaft seal

9. Housing shells

10. Type plate

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### 2. Available versions, main data

**Order example:** R 5,8 ... - PYD

#### Table 1a: Basic type coding, see also sect. 1

<table>
<thead>
<tr>
<th>Design, cylinder arrangement</th>
<th>Number of pump cylinders</th>
<th>Delivery flow coding (guideline figure Q in (lpm) at 1450 rpm)</th>
<th>Drive power (standard motor)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Piston diameter (mm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4   5   6   7   8   9   10   12   13   14   15   16</td>
<td></td>
</tr>
<tr>
<td>2   3   5-cylinder pump</td>
<td>700 550</td>
<td>0.18 0.28 0.43 0.56 0.73 0.92</td>
<td>0.25 to 0.55</td>
</tr>
<tr>
<td></td>
<td>(0.13) (0.20) (0.28) (0.38) (0.50) (0.64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3   4   6-cylinder pump</td>
<td>700 600</td>
<td>0.27 0.42 0.64 0.81 1.1 1.35</td>
<td>0.25 to 0.75</td>
</tr>
<tr>
<td></td>
<td>(0.19) (0.29) (0.42) (0.58) (0.75) (0.95)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5   6   8-cylinder pump</td>
<td>700 550 450 350 250 100 200 160</td>
<td>0.46 0.7 1.08 1.39 1.77 2.27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.31) (0.49) (0.71) (0.96) (1.26) (1.59)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1b: Delivery flow coding**

<table>
<thead>
<tr>
<th>Design, cylinder arrangement</th>
<th>Number of pump cylinders</th>
<th>Delivery flow coding (guideline figure Q in (lpm) at 1450 rpm)</th>
<th>Drive power (standard motor)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Piston diameter (mm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4   5   6   7   8   9   10   12   13   14   15   16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1   2   3-cylinder pump</td>
<td>700 550</td>
<td>0.18 0.28 0.43 0.56 0.73 0.92</td>
<td>0.25 to 2.2</td>
</tr>
<tr>
<td></td>
<td>(0.13) (0.20) (0.28) (0.38) (0.50) (0.64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2   3   5-cylinder pump</td>
<td>700 600</td>
<td>0.27 0.42 0.64 0.81 1.1 1.35</td>
<td>0.25 to 2.2</td>
</tr>
<tr>
<td></td>
<td>(0.19) (0.29) (0.42) (0.58) (0.75) (0.95)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3   4   6-cylinder pump</td>
<td>700 550 450 350 250 100 200 160</td>
<td>0.46 0.7 1.08 1.39 1.77 2.27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.31) (0.49) (0.71) (0.96) (1.26) (1.59)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table 2: Versions

<table>
<thead>
<tr>
<th>No coding</th>
<th>Standard</th>
<th>A</th>
<th>Arrangement of the shaft seals e.g. R 3.6A (see description in sect. 5.2 on page 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>H</td>
<td>Hollow shaft (only avail. for design 6010)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HFA</td>
<td>Version for water based fluids; only avail. for design 6010 to 6016 and piston diameter 6, 7, 8, 10, and 12. Type RG should be used, see also note <em>Pressure fluids</em> in sect. 3.</td>
</tr>
</tbody>
</table>

#### Table 3: Seals

<table>
<thead>
<tr>
<th>No coding</th>
<th>NBR (standard)</th>
<th>PYD</th>
<th>FKM seals (Viton)</th>
<th>AT</th>
<th>EPDM seals</th>
</tr>
</thead>
</table>

### Notes:

1. The operating pressure should be restricted for applications with continuous operation where the subsequent load cycles are all at the upper end of the pressure range (>75%) e.g. accumulator charging etc.
   It is advisable for an economic service life of the bearings to restrict the operating pressure of the respective pump element diameter to about 75% of its original specification. Another pump with smaller but more pump elements should be selected, if this is not possible.

2. For ancillary parts, like bellhousings, flex-couplings etc., see D 6010 H

3. Figures in brackets apply to design 7631

4. Type RG not available for design 7631
3. Further characteristic data

Nomenclature  Radial piston pump, constant delivery pump
Type of fastening  Via the flange at the drive shaft side
Hydraulic connection  Via fittings ISO 228/1 (BSPP); For port size, see dimensional drawings in sect. 4
Drive and direction of rotation  Via flex-coupling; direction of rotation as desired, see also "Direction of flow"
Drive speed range  
- continuous: R: 100 ... 2000 rpm, RG: 1000 ... 2000 rpm
- 2800 rpm admissible for brief periods; note in this case that bellhousings, flex-couplings, etc. (D 6010 H) are available only for industrial standard motor sizes 71 to 200 L. The output generated by such motors (DIN 42 677) may require a reduction of the maximum pressure rating as the delivery flow will twice of the one stated in "Delivery flow" (sect. 2).

Installed position  See sect. 5, any angle between horizontal and vertical
Direction of flow  Determined by intake and pressure port, independent of the direction of rotation
Operating pressure  
- Pressure side: Depending on piston diameter, see sect. 2
- Suction side: 
  - - 0.3 bar ... +1 bar  (ca. 0.7 bar abs ... ca. 2 bar abs.)
  - +2 bar  (3 bar abs.) with type R(G)...-A
  Observe note in sect. 5.2!

Delivery flow  See delivery flow coding in sect. 2
Guideline depending on speed  
\[ Q_{pu} = V_p \cdot n \cdot \eta_{vol} \cdot 10^{-3} \text{lpm} \]
With:  
\[ V_{geo} \text{ in cm}^3/\text{rev.} \quad \text{Delivery flow, sect. 2} \]
\[ n \text{ in rpm} \quad \text{Speed} \]
\[ \eta_{vol} = 0.98 \quad \text{Volumetric efficiency} \]
**Attention:** The conditions listed below may cause reduced efficiency:
- Viscosities > 500 mm²/s and < 10 mm²/s
- Operating pressure < 20 bar
- Speed > 2000 rpm; especially with small piston-

Mass (weight)  
<table>
<thead>
<tr>
<th>Design</th>
<th>7631</th>
<th>6010</th>
<th>6011</th>
<th>6012</th>
<th>6014</th>
<th>6016</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cylinders</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>1 and 2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>approx. (kg)</td>
<td>3</td>
<td>3.1</td>
<td>3.2</td>
<td>2.5</td>
<td>3.1</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Hydraulic fluid:  
Hydraulic oil acc. to DIN 51524 table 1 to 3  
10 ... 68 mm²/s at 40°C (ISO VG 10 to 68 conf. DIN 51 519)  
Viscosity range: 10 to 500 mm²/s  
Viscosity limits (start viscosity):  
- Type R 0,18 ... R 2,27: min. approx. 4; max. approx. 800 mm²/s  
- Type R 0,3 ... R 91,2: min. approx. 4; max. approx. 1500 mm²/s  
Also suitable are biologically degradable pressure fluids type HEPG (Polyalkylenglykol) and HEES (synth. Ester) at operation temperatures up to approx. +70°C. Version type R...-HFA is also suited for water based pressure fluids, but their restricted lubrication abilities prevent their use above approx. 75% of the max. pressure ratings pmax (see table 1b).

Temperature:  
Ambient: approx. -40...+80°C  
Fluid: -25...+80°C, pay attention to the viscosity range!  
Start temperature down to -40°C are allowable (Pay attention to the viscosity range during start), as long as the operation temperature during subsequent running is at least 20K higher. Biological degradable pressure fluids: Pay attention to manufacturer’s information. With regard to the compatibility with sealing materials do not exceed +70°C.

Power consumption  
\[ P_{kw} = \frac{P_{bar} \cdot Q_{rpm} \cdot c}{600 \cdot \eta_T} \quad \text{Approximate figure common formula applying} \]

**Abbreviations:**  
\[ P_{kw} = \text{Required power at the pump drive shaft in kW} \]
\[ P_{bar} = \text{Exploited pressure in bar} \]  
\[ \text{(consumer pressure + back pressure)} \]
\[ Q_{rpm} = \text{Delivery flow in lpm, at 1450 rpm, see delivery flow codings in sect. 2;} \]  
\[ \text{At differing speed ratings} \ n_r \text{ in Q}_{rpm}, \text{delivery flow coding multiplied with} \ n_r / 1450 \]
\[ c = \text{Theoretical factor which takes the pulsation of the pump into account} \]  
\[ 3 \ldots 42 \text{ cylinders: } c = 1 \]
\[ 2\text{-cylinder pump: } c = 1.3 \ldots 1.5 \]
\[ 1\text{-cylinder pump: } c = 2.7 \ldots 3.1 \quad \text{(highest figure with piston-} \text{C 12 \ldots 16 mm)} \]
\[ \eta_T = \text{Total efficiency, average, 0.8 \ldots 0.85} \]
4. Dimensions

4.1 Hydraulic pumps

All dimensions in mm, subject to change without notice!

Design 7631
2-, 3-, and 5-cylinder pumps

Suction port G 3/8 (BSPP)

Bleeder

4 x M8, 11 deep

Pressure port G 1/4 (BSPP)

Design 6010
1- and 2-cylinder pump

Bleeder

4 x M8, 12 deep

3-cylinder pump

Bleeder

4 x M8, 12 deep

Design 6011
1-radial pump

Bleeder

4 x M10, 14 deep

For missing dimensions, see 3-cylinder pump below!

Version with hollow shaft, coding H (table 2)
Design 6012
2-radial pump

Design 6014
4-radial pump

Design 6016
6-radial pump
5. **Notes regarding installation**

The pump must always be located below the anticipated minimum fluid level during operation no matter whether the pump is installed inside the tank (hydraulic power packs) or outside (motor pump). The housing shell forms a complete, self-contained unit around the cylinders radials, and can be only properly bled (after a refill) if it is completely immersed in the fluid. For a detailed description of installation, bleeding and initial operation, see sect. 5 in D 6010 H.

5.1 **Running noise**

The noise level curves shown here present the results of practical measurements in a test area, making allowance for any deviation of the noise levels measured. Pumps with a small delivery flow (small piston diameter) within each group will generally provide results shown by the lower curve, pumps with a larger delivery flow (13-16 mm piston diameter) will generally be in the middle or top of the range shown.

<table>
<thead>
<tr>
<th>Measuring conditions:</th>
<th>Design 7631</th>
<th>Design 6010</th>
<th>Design 6011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiet operating area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interference noise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>level approx. 37dB(A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured 1m above</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ground, 1m away from</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>measured object</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring unit:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precision sound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>level meter DIN IEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>651 Kl. I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscosity of oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>during measurement:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>approx. 50 mm²/s</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.2 **Slightly charged pumps** (above approx. 0.4 ... 0.5 bar)

Standard:
Sealing lips facing towards each other-no suffix

Version R .. A:
Sealing lips facing to the inside, for intake pressure exceeding approx. 0.4 bar

The drive shaft is sealed to the outside on the shaft journal by two subsequent shaft seals. The sealing lips of these seal rings face towards each other with standard applications. This is advantageous as it prevents air entering during the intake (vacuum in the pump housing) and no fluid can escape even if the fluid level is located higher than the suction port (slight overpressure in the pump housing, due to the weight of the oil column).

The pumps are also available with both sealing lips facing to the inside advisable for conditions where the tank is located much higher than the pump (i.e. several meters) or a tank is permanently pressurized (p₂ > 0.4 bar).

Please note, however, that any charge pressure above 1 bar (2 ... 3 bar is still admissible) may considerably reduce the service life of the sealing lips. It is therefore only acceptable, when the pump stands still for prolonged periods between operation.