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**Background**

Energy efficiency and plug-and-play installation are becoming crucial → self-contained electro-hydraulic cylinders

A few solutions exist based on throttleless systems (no functional power dissipations) with 1* or 2** pumps

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Passive Load-Holding

A particular self-contained cylinder was recently proposed* →
load-holding valves + 4-quadrant + energy recovery

Main features: variable-speed pump (P), sealed reservoir (AC),
load-holding valves (LHVs) operated electro-hydraulically (EV)

The Issue (Position Drop)

Driving the actuator requires **disengaging the load-holding valves → piston drop** during this operation (system controlled in open-loop position control)

<table>
<thead>
<tr>
<th>Desired piston position [mm]</th>
<th>Commanded pump speed [rev/min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>200</td>
<td>0</td>
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<tr>
<td>0</td>
<td>0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Load-holding valve’s cmd [-]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
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<table>
<thead>
<tr>
<th>Piston position [mm]</th>
<th>Load-holding valve’s cmd [-]</th>
<th>Pump speed [rev/min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>52</td>
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<td>0</td>
</tr>
<tr>
<td>48</td>
<td>0</td>
<td>400</td>
</tr>
</tbody>
</table>

Position drop ≈ 2.5 mm

Position drop ≈ 4 mm

Hagen and Padovani
The Solution (Pressure Control)

The **2-stage pressure control** builds up the pump pressure by running the pump before disengaging the load-holding valves → **position drop eliminated!**

![Diagram showing pressure control](image)