# HMV Variable Motors

## Data and Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>HMR 55</th>
<th>HMR 75</th>
<th>HMR 105</th>
<th>HMR 135</th>
</tr>
</thead>
<tbody>
<tr>
<td>cm 3/rev</td>
<td>55</td>
<td>75</td>
<td>105</td>
<td>135</td>
</tr>
<tr>
<td>in 3/rev</td>
<td>3.36</td>
<td>4.57</td>
<td>6.40</td>
<td>8.23</td>
</tr>
<tr>
<td>Pressure Ratings</td>
<td>Nominal 5000 PSIG</td>
<td>Maximum 6090 PSIG</td>
<td>Peak 7250 PSIG</td>
<td></td>
</tr>
<tr>
<td>Rated Speed Max. Disp.</td>
<td>4000</td>
<td>3700</td>
<td>3300</td>
<td>3000</td>
</tr>
<tr>
<td>Rated Speed Min. Disp.</td>
<td>5000</td>
<td>4600</td>
<td>4100</td>
<td>3700</td>
</tr>
<tr>
<td>Envelope Size L</td>
<td>9.0</td>
<td>9.5</td>
<td>10.5</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>8.0</td>
<td>8.2</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>9.2</td>
<td>9.8</td>
<td>9.8</td>
</tr>
<tr>
<td>Weight</td>
<td>75.0</td>
<td>71.0</td>
<td>73.0</td>
<td>125.0</td>
</tr>
<tr>
<td>HP Rating Count</td>
<td>107.0</td>
<td>161.0</td>
<td>205.0</td>
<td>241.0</td>
</tr>
</tbody>
</table>
HMV Variable Motors
Proportional Hydraulic Control and Pressure Override
Electric Brake Pressure Shutoff
Electric Maximum Displacement Override
Purging System

Circuit Diagram

EXPLANATIONS

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Main ports SAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Control pressure port</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Drain (filling, vent) ports. Connection enabling case to be filled with oil.</td>
<td></td>
</tr>
</tbody>
</table>

Flow in at port A: Direction of rotation left
Flow in at port B: Direction of rotation right

Solenoid switching operations
M1/M2: d.c. solenoid 12 V 12 V

El. Cold power rating $P_p < 26W$

M1/M2: de-energized: pressure-controlled
M1: de-energized: A main port side
M2: energized: B main port side
M1: energized: acting as fixed displacement motor HMF ... - 02 (qmax operation)

Pressure range 8 - 14 bar
HMV Variable Motors
Proportional Hydraulic Control and Pressure Override
Electric Brake Pressure Shutoff
Electric Maximum Displacement Override
Purging System

Functional Description

The variable displacement motor HMV 02 is a swash-plate axial piston motor for the closed circuit.
The motor is equipped with a proportional hydraulic displacement control and a pressure override (regulator).
As an additional installation the motor has:
- electric maximum displacement override
- electric brake pressure shut-off
- purging system

Functioning of infinitely variable displacement

In this control system, the motor operates at “maximum displacement.” The motor is control pressure dependent, with an infinitely adjustable displacement between a maximum and a minimum setting.
Servo pressure >16 bar is delivered to the control mechanism from the charge pressure (see circuit diagram) via channel “E.” This servo pressure is transmitted via the pilot valve (1) in the normal position to the maximum displacement piston. The second displacement piston is relieved through the pilot valve into the motor casing. When a control pressure is applied at port “X,” the pilot valve (1) is moving against a spring force. This provides control pressure from port “E” to the actuator cylinder piston for minimum displacement and releases the actuator cylinder piston for maximum displacement to the tank (assumed that the system pressure < regulation begin of pressure regulator and solenoid M1 is not energized).
The pressure in the actuating cylinder is increased until the swash plate swings back, causing equilibrium to prevail between the control pressure “X” and the feedback spring. The pilot then has a balance position. The motor holds this position until the control pressure “X” changes.
This feedback system permits exact actuation of all qmax and qmin intermediate positions as a function of the control pressure at port “X.” Adjustment from qmax towards qmin is proportional to the control pressure (normally 8–14 bar).
Functional Description

Functioning of pressure regulator

In the unregulated condition, the motor operates at a displacement proportional to control pressure, which is applied at connection “X” (see functioning of infinitely variable displacement). Following attainment of a set pressure (regulation begin), the motor swings steplessly towards “maximum displacement.”

The two main connections of the HMV are designated A and B (see circuit diagram). Depending on the position of the electrically operated 3/2 directional control valve M2, one of the channels is connected with regulator 2. The start of the feedback control is determined by the pressure setting of the regulator 2, the pressure at which the motor begins to move towards “maximum displacement.” As soon as the pilot in the regulator 2 is shifted against the spring force, the control pressure “X” is relieved through the pilot valve M1 into the motor casing (hydraulic tank). Adaption to the required torque is effected steplessly through the changing of the swash angle.

Diagram
**Functional Description**

**Functioning of electric displacement override**

For a variety of applications (deliberate switching off the high-pressure influence in specific drive operations) it is necessary that the regulating motor can also be set below start of regulating control to “maximum displacement.” For this purpose the valve (2) is switched electrically with the solenoid M1.

**Functioning of electric brake pressure shut-off**

The electric brake pressure shut-off prevents that the back pressure in braking mode of the closed loop acts on the regulator. The solenoid M2 is operated by selection of the “forward” or “reverse” direction of travel. Depending on whether the solenoid M2 is energized or de-energized, the high pressure can only pass to the regulator (2) from one high-pressure side A or B. If pressure is reversed in the braking operation, the increasing brake pressure cannot affect the regulator and the motor remains in qmin.

**Example: Connection “A” is the admission side**

The oil flow in this channel flows to the hydraulic motor. If the pressure is increased above begin of regulation set in the regulator (2) by increasing the tractive resistance in A, then the motor is regulating. During braking the direction of flow and direction of rotation are maintained but the higher pressure now occurs in the return side “B.” This, however, has no effect on the regulator. The hydraulic motor remains in the qmin position or returns to this position (exception, electric qmax operation actuated). It brakes at the torque resulting from qmin, which in vehicles corresponds to a lightly braked coasting behaviour.
Linde purging system

The hydraulic motor is equipped with a Linde purging system. This comprises two scavenging systems:

- circuit scavenging
- case scavenging

Circuit scavenging

If temperature problems occur (e.g. in the case of high ambient temperature), the temperature in the closed circuit can be substantially reduced by the scavenging system. The shuttle valve (3) connects the low-pressure side to the discharge valve (4). The purge oil can then be cooled and fed back into the system via a make up circuit (not in motor) to cool the closed loop.

Case scavenging

The heat generated in the rotating group of the hydraulic motor (bearings, linkages, slide faces) can only be discharged from the motor casing through the drained-off leakage. Under certain unfavourable operating conditions, e.g. high motor speed and low operating pressure, the resulting leakage is not sufficient to dissipate the “frictional heat.”

With the Linde purging system, a quantity of oil flows from the discharge valve (4) at about 10 l/min as a cooling scavenging oil, into the casing of the hydraulic motor and then, after having scavenged the casing, drains off together with the resultant leakage.
Functioning of the Linde purging system

When high-pressure lines are without load and have only boost pressure (e.g. when the pump is in the neutral position), the two pistons of the shuttle valve (3) (Fig.1) are in the spring-centered position. Operating fluid is unable to flow to the discharge valve (4) from either the high-pressure connection A or the high-pressure connection B.

However, if high pressure (HP) builds up on, for example the A side, then this high pressure displaces the piston A1, driving the piston B1 towards the low-pressure (LP) connection B (Fig.2). The conical seat (5) on piston A1 acts as a stop, thereby simultaneously preventing high-pressure fluid from being transferred out of the spring chamber A1 towards the discharge valve (4).
 HMV Variable Motors
 Proportional Hydraulic Control and Pressure Override
 Electric Brake Pressure Shutoff
 Electric Maximum Displacement Override
 Purging System

Basic Design of Rotating Group

EXPLANATIONS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shaft</td>
</tr>
<tr>
<td>2</td>
<td>Piston assembly</td>
</tr>
<tr>
<td>3</td>
<td>Cylinder barrel</td>
</tr>
<tr>
<td>4</td>
<td>Swash plate</td>
</tr>
<tr>
<td>5</td>
<td>Port plate</td>
</tr>
</tbody>
</table>
HMV Variable Motors
Proportional Hydraulic Displacement Control
Purging System

Circuit Diagram

EXPLANATIONS

<table>
<thead>
<tr>
<th></th>
<th>Working connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Auxiliary control signal</td>
</tr>
<tr>
<td>X</td>
<td>Control pressure connection (Control pressure range 8 ... 14 bar)</td>
</tr>
<tr>
<td>E</td>
<td>Servo pressure connection (PE = 20 ... 40 bar)</td>
</tr>
<tr>
<td>L</td>
<td>Drain (filling, vent) ports</td>
</tr>
<tr>
<td>U</td>
<td>Connection enabling case to be filled with oil.</td>
</tr>
</tbody>
</table>

Flow in at port **A**: Direction of rotation left
Flow in at port **B**: Direction of rotation right

<table>
<thead>
<tr>
<th>Valve pressure</th>
<th>Drain rate approx.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 bar</td>
<td>5 l/min</td>
</tr>
<tr>
<td>10 bar</td>
<td>9 l/min</td>
</tr>
</tbody>
</table>

Connection F for auxiliary control signal, special cases only (normally closed)
In this control system, the motor operates nominally at “maximum displacement.” The motor is control pressure dependent, with an infinitely adjustable displacement between a maximum and minimum setting.

Servo pressure (minimum 20 bar) is delivered to the displacement mechanism from the pilot circuit via the connection “E.” This servo pressure is transmitted, via the pilot valve (1) in the normal position, (see circuit diagram), the maximum displacement piston. The second displacement piston is relieved through the pilot valve (1) into the motor casing.

When a control pressure is applied at connection “X,” the pilot valve (1) is displaced against a spring force so the control just opens the displacement control piston minimum displacement side to port “E” and connects the control piston maximum displacement side to tank. The pressure in the actuating cylinder is increased until the rocker swings back, causing equilibrium to prevail between the control pressure “X” and the feedback spring. The pilot then has a balance position. The motor holds this position until the control pressure “X” changes.

This feedback system permits exact actuation of all Vmax and Vmin intermediate positions as a function of the control pressure at connection “X.” Adjustment from Vmax towards Vmin is proportional to the control pressure (normally 8–14 bar), see diagram. For special cases, an auxiliary pressure signal can be applied to the back side of the pilot valve (1) via the normally closed connection “F.” This pressure signal supports the force of the feedback spring.

This, however, requires a plug to be located in the connecting channel (in the control stage mounting) to the casing.

Diagram
Linde purging system

The hydraulic motor is equipped with a Linde purging system. This comprises two scavenging systems:

- circuit scavenging
- case scavenging

Circuit scavenging

If temperature problems occur (e.g. in the case of high ambient temperature), the temperature in the closed circuit can be substantially reduced by the scavenging system. The shuttle valve (8) connects the low-pressure side to the discharge valve (9). The purge oil can then be cooled and fed back into the system via a make up circuit (not in motor) to cool the closed loop.

Case scavenging

The heat generated in the hydraulic motor’s rotating group (bearings, linkages, slide faces) can only be discharged from the motor casing through the drained-off leakage. Under certain unfavourable operating conditions, e.g. high motor speed and low operating pressure, the resulting leakage is not sufficient to dissipate the “frictional heat.”

With the Linde purging system, a quantity of oil flows from the discharge valve (9) at about 10 l/min, as a cooling scavenging oil, into the casing of the hydraulic motor and then, after having scavenged the casing, drains off together with the resultant leakage.
Functioning of the Linde purging system

When high-pressure lines are without load and have only boost pressure (i.e., when the pump is in the neutral position), the two pistons of the shuttle valve (8) (Fig.1) are in the spring-centered position. Operating fluid is unable to flow to the discharge valve (9) from either the high-pressure connections (A or B).

However, if high pressure (HP) builds up on, for example, the A side, then this high pressure displaces the piston A1, driving the piston B1, towards the low-pressure (LP) connection B (Fig.2). The conical seat (10) on piston A1 acts as a stop, thereby simultaneously preventing high-pressure fluid from being transferred out of the spring compartment A1 towards the discharge valve (9).
HMV Variable Motors
Proportional Hydraulic Displacement Control
Purging System

EXPLANATIONS
1 Shaft
2 Swash plate
3 Working piston
4 Cylinder barrel
5 Valve plate
**EXPLANATIONS**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>E</th>
<th>L</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working connections SAE (6000psi)</td>
<td>Servo pressure connection (PE = 20 .... 40 bar)</td>
<td>Drain (filling, vent) ports</td>
<td>Connection enabling case to be filled with oil.</td>
<td></td>
</tr>
</tbody>
</table>

Flow in at port (A): Direction of rotation left
Flow in at port (B): Direction of rotation right
Servo pressure of minimum 20 bar is delivered to the control mechanism from the pilot circuit via connection port “E.” This servo pressure is transmitted via pilot valve (1) in its normal position to one of two control pistons, which effects a move towards “max. displacement,” as long as the proportional solenoid “Mp” stays de-energized. The second control piston is relieved to the inside of the motor housing via pilot valve (1).

When a pre-selected current is applied to the proportional solenoid “Mp,” this generates a proportional magnetic force $F_{m1}$ on the pin, thereby pushing the pilot valve (1) against the feedback spring $F_{m2}$, causing the control edges to open channel “E” with $p_{con}$ (min) and to connect to tank with $p_{con}$ (max). Pressure in the actuating cylinder is increased until the swash plate swings back and establishes an equilibrium condition of the forces $F_{m1}$ and $F_{m2}$ of the feedback spring. The pilot then is in a balance position.

The motor will hold this position until the current signal is changed. Owing to this feedback system, any intermediate positions from $q_{max}$ to $q_{min}$ can be achieved accurately by means of the current at the proportional solenoid. The current values in the diagram below are to be understood as examples.

**Speed sensor CEH 10/..**

This hydraulic motor is equipped with an RPM sensor. This sensor provides 20 impulses per revolution. These can be handled by suitable electronics, e.g. to control or supervise rotational speed.

Diagram
Linde purging system

The hydraulic motor is equipped with a Linde purging system. This comprises in fact two systems:
- circuit scavenging
- case flushing

Circuit scavenging

If temperature problems occur (e.g. in the case of high ambient temperature), the temperature in the closed circuit can be substantially reduced by the scavenging system. The shuttle valve (8) connects the low-pressure side to the discharge valve (9). The purged oil can then be cooled and fed back into the system via a make up circuit (not in motor) to cool the closed loop.

Case flushing

The only way to get rid of the heat generated in the rotating group of the hydraulic motor (bearings, linkages, slide faces) is through the leakage spill. Under certain unfavourable operating conditions, e.g. high motor speed and low operating pressure, the resulting leakage may be insufficient to dissipate the “frictional heat.”

With the Linde scavenging system, a quantity of oil flows from the discharge valve (9) at about 10 l/min, as a scavenge-cooling oil, into the casing of the hydraulic motor and then, after having scavenged the casing, drains off together with the resultant leakage.
Functioning of the Linde purging system

When high-pressure lines are without load and have only boost pressure (e.g. when the pump is in the neutral position), the two pistons of the shuttle valve (8) (Fig.1) are in the spring-centered position. Operating fluid is unable to flow to the discharge valve (9) from the high-pressure connection A nor the high-pressure connection B. However, if high pressure (HP) builds up on, for example, the A side, then this high pressure displaces the piston A1, driving the piston B1 towards the low-pressure (LP) connection B (Fig.2). The conical seat (10) on piston A1 acts as a stop, thereby simultaneously preventing high-pressure fluid from being transferred out of the spring compartment A1 towards the discharge valve (9).
**Functional Description**

**Functioning of the Linde purging system**

When high-pressure lines are without load and have only boost pressure (e.g. when the pump is in the neutral position), the two pistons of the shuttle valve (8) (Fig.1) are in the spring-centred position. Operating fluid is unable to flow to the discharge valve (9) from the high-pressure connection A nor the high-pressure connection B.

However, if high pressure (HP) builds up on, for example, the A side, then this high pressure displaces the piston A1, driving the piston B1 towards the low-pressure (LP) connection B (Fig.2). The conical seat (10) on piston A1 acts as a stop, thereby simultaneously preventing high-pressure fluid from being transferred out of the spring compartment A1 towards the discharge valve (9).
Basic Design of Rotating Group

EXPLANATIONS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shaft</td>
</tr>
<tr>
<td>2</td>
<td>Swash Plate</td>
</tr>
<tr>
<td>3</td>
<td>Working Piston</td>
</tr>
<tr>
<td>4</td>
<td>Cylinder Barrel</td>
</tr>
<tr>
<td>5</td>
<td>Valve Plate</td>
</tr>
<tr>
<td>6</td>
<td>Speed Sensor CEH 10/..</td>
</tr>
<tr>
<td>7</td>
<td>Impulse Wheel</td>
</tr>
</tbody>
</table>