FPB – FULL
HYDRAULIC POWER BRAKE

WABCO
FPB

Full Hydraulic Power Brake

Edition 5

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Further information

Technical documents can be found on the Internet by entering an index word in the WABCO Online Product Catalogue INFORM:
http://www.wabco-auto.com
=> INFORM => Index

You will find available repair kits and spare parts on the Internet by entering the device product number in the WABCO Online Product Catalogue INFORM:
http://www.wabco-auto.com
=> INFORM
=> Product number
=> Repair
FPB – Full Hydraulic Power Braking System

At present, the majority of special vehicles, construction machines of up to approx. 10 t dead weight are equipped with a hydraulic manual braking system. Vehicles with a greater dead weight usually have Full Hydraulic Power Braking Systems.

For wet inboard disc brakes, the WABCO Full Hydraulic Power Braking System is a good choice because it explicitly takes into account the requirements of construction machines.

The components of the Full Hydraulic Power Braking System are suitable for fluids on the basis of mineral oils and some bio-fluids which means that the fluids present in the construction vehicle's hydraulic system can be used as the energy transmitter for the braking system.

All devices have been designed to account for the higher viscosity of such fluids as compared to the brake fluid.

The components are particularly robust to ensure that they are capable of withstanding the severe strain of everyday operation.

The legal requirements for the FPB with regard to the size of its energy accumulators, output of its energy source and the properties of the warning system are defined in the EC directive 98 / 12 / EC, Annex IV in Section C (see paperback "Legal Requirements" 2004 edition" or chapter "Legal requirements in Europe" in this document).

The FPB system is not really suitable for operating a trailer braking system. This requires the installation of a system for supplying compressed air with a hydraulically operated Trailer Control Valve (470 015 ... 0). The hand brake facility for the trailer may then be operated via a hydro pressure switch, a solenoid valve and a relay valve (pneumatic).

In order to take into account the trend towards dual circuit service braking systems, we recommend that > 25 km/h. vehicles be fitted with a dual circuit FPB system.

A single circuit system would already satisfy the German road traffic regulations for construction machines however.

CAUTION

If the brake volume is greater than 75 cm³, at least the first (top) circuit of the foot operated brake valve must be equipped with a relay valve.

Always check the response and threshold times. It may be necessary to equip both circuits of the service brake system with relay valves.
## System proposal

### Single circuit

All pipes of brake line NW 10

### Port designations

- 0 Suction port
- 1 Energy supply
- 2 Energy delivery
- 5 Return connection

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System proposal
Dual circuit

Item     | Quantity | Designation          | Order number
---------|----------|----------------------|---------------
1         | 1        | Pump                 |               
2         | 1        | Pressure filter      |               
3         | 1        | Cutoff valve         | 477 397 015 0 
4         | 1        | Brake valve          | 467 406 ... 0 
5         |          |                      |               
6         |          |                      |               
7         |          |                      |               
8         | 1        | Reservoir            |               
9         |          | Wheel brake cylinder |               
10        |          |                      |               
11        | 1        | Pressure switch      | 441 014 049 0 
12        | 2        | Pressure switch      | 441 014 055 0 
13        |          |                      |               
14        | 3        | Pressure test connection |               
15        |          |                      |               
16        |          |                      |               
17        | •        | Accumulator          | 458 501 ... 0 
18        | •        | Accumulator          | 458 501 ... 0 
19        |          |                      |               
20        |          |                      |               

Port designations
- 0 Suction port
- 1 Energy supply
- 11 Energy supply Circuit 1
- 12 Energy supply Circuit 2
- 2 Energy delivery
- 21 Energy delivery Circuit 1
- 22 Energy delivery Circuit 2
- 23 Energy delivery Circuit 3

for foot-operated brake valve:
- 24 Test connection (pressure switch)
- 25 Test connection (pressure switch)

all pipes of brake line NW 10
System proposal
Dual circuit with auxiliary braking system

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<td>Spring brake actuator</td>
<td>427 001</td>
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For foot-operated brake valve:
- Suction port: 24, 25 (Hydraulic accumulator)
- Energy supply: 26, 27 (Hydraulic accumulator)
- Energy supply Circuit 1: 28 (Pressure switch)
- Energy supply Circuit 2: 28 (Pressure switch)
- Energy delivery: 4 (Control port)
- Energy delivery Circuit 1: 5 (Return connection)
- Energy delivery Circuit 2: 51 (Return connection Circuit 1)
- Energy delivery Circuit 3: 52 (Return connection Circuit 2)

Port designations:
- 0: Suction port
- 1: Energy supply
- 11: Energy supply Circuit 1
- 12: Energy supply Circuit 2
- 2: Energy delivery
- 21: Energy delivery Circuit 1
- 22: Energy delivery Circuit 2
- 23: Energy delivery Circuit 3

All pipes of brake line NW 10
Port designations

- **Item**: 0, 1, 11, 12, 2, 21, 22, 23
- **Quantity**: 1, 1, 1, 1, 1, 1, 2, 1
- **Designation**:
  - 0: Suction port
  - 1: Energy supply
  - 11: Energy supply Circuit 1
  - 12: Energy supply Circuit 2
  - 2: Energy delivery
  - 21: Energy delivery Circuit 1
  - 22: Energy delivery Circuit 2
  - 23: Energy delivery Circuit 3
- **Order number**:
  - 24: Test connection (pressure switch)
  - 25: Test connection (pressure switch)

---

**841 300 332 0**

*System proposal*

*Dual circuit with relay valves*

---

**Item** | **Quantity** | **Designation** | **Order number**
--- | --- | --- | ---
1 | 1 | Pump | 
2 | 1 | Pressure filter | 
3 | 1 | Cutoff valve | 477 397 ... 0
4 | 1 | Brake valve | 467 406 ... 0
5 | 1 | Park brake valve | 467 410 ... 0
6 | | | 
7 | 2 | Relay valve | 477 411 ... 0
8 | 1 | Reservoir | 
9 | | Wheel brake cylinder | 
10 | 1 | Spring brake actuator | 427 001 ... 0

---

**Item** | **Quantity** | **Designation** | **Order number**
--- | --- | --- | ---
11 | 1 | Pressure switch | 441 014 049 0
12 | 2 | Pressure switch | 441 014 055 0
13 | 1 | Pressure switch | 441 014 044 0
14 | 4 | Pressure test connection | 
15 | 1 | Accumulator | 458 501 071 0
16 | | Accumulator | 458 501 ... 0
17 | | Accumulator | 458 501 ... 0
18 | | Accumulator | 458 501 ... 0
19 | 1 | Accumulator | 458 501 071 0
20 | 1 | Accumulator | 458 501 071 0

---

*all pipes of brake line NW 10*
**System proposal**

Compact valve with brake valve and pump control valve

---

**Port designations**

1. Energy supply
2. Energy delivery
2.1 Hydraulic accumulator (circuit 1)
2.2 Hydraulic accumulator (circuit 2)
2.3 Brake circuit 3 (park brake)
2.4 Pressure switch
5. Return port
6.1 Service brake (circuit 1)
6.2 Service brake (circuit 2)
6.3 Pressure switch (circuit 1)
6.4 Pressure switch (circuit 2)

---

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Device description
**Purpose**

The spring brake actuator has the task to generate the braking force for the wheel brake in secondary and parking brake systems.

**Operation**

**Standby position**

When driving, the output pressure from the hand brake valve acts directly on port 1 of the spring brake actuator. The secondary or parking brake is released.

**Braking position**

When the park brake valve is actuated, the hydraulic pressure is reduced in accordance with the angular position of the park brake lever.

As the pressure in the hydraulic part (A) of the spring brake actuator is reduced, the force of the decompressing compression spring (B) retracts the piston rod (C) in the direction of the actuator's axis, thus actuating the wheel brake. The spring brake actuator’s maximum braking force is reached when the pressure drops to zero.

**Quick release function**

Some variants are available with a quick-release function.

This permits, in the event of the pressure in the hydraulic part (A) failing, the wheel brake to be released by applying a blow of the hammer in the direction of the arrow (F) thus cancelling the friction-locked connection established between compression spring (B) and piston rod (C) and actuating the quick-release facility (D).

As the pressure in the hydraulic part (A) builds up again, the connection between compression spring (B) and piston rod (C) is established once more and the spring brake actuator is fully operational again.

**Emergency release function**

In the case of spring brake actuators without a quick-release function, the parking brake can still be released should the hydraulic pressure fail. To do so, the hexagon nut (6) on piston rod (K) is removed from the yoke end (C1). An open-jawed spanner (jaw size 13) is positioned on the wrench flat (L) of the piston rod (K). The piston rod (K) is then turned in such a way that the yoke end (C1) is shifted towards the brake lever.
Replacing the bellows

Remove clamps (2; 3 or H) from the bellows. Replace them if necessary when fitting the new bellows. Pull off the defective bellows (1). Push on new bellows and fasten with the corresponding clamps (2; 3 or H).

Replacing the yoke end

When replacing the yoke end (5) on actuators without a quick-release function, immobilise the piston rod (K) by applying a spanner (jaw size 13). Remove hexagon nut (6) and unscrew the yoke end (5) from the piston rod. The new yoke end is screwed into the piston rod until the original piston rod length is reached again (see outline drawing: distance from centre yoke hole to end face of port 1). Secure piston rod again by means of the hexagon nut.

Technical data

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| Operating pressure | max. 150 bar |
| Stroke | 80 ± 3 mm |
| Release pressure | 87 ± 4 bar | 60 ± 4 bar | 40 ± 4 bar | 95 ± 6 bar | 60 ± 4 bar |
| Thermal range of application | -30°C to +80°C |
| Medium | Mineral oil 10 to 2000 mm²/s |
| Output force at 0 mm stroke | 2745 N | 2270 N | 1505 N | 3000 N | 2270 N |
| Output force at 80 mm stroke | 4320 N | 3250 N | 2205 N | 5000 N | 3250 N |
| Piston rod pivoting range | 3° on all sides |
| Emergency release function | No | No | No | Yes | Yes |
| Yoke end | No | Yes | Yes | Yes | Yes |
| Bellows | Yes | Yes | Yes | Yes | Yes |
| Weight | 6.5 kg | 6.8 kg | 8.0 kg |

Repair work

**CAUTION**
For safety reasons replace the complete spring brake actuator if other parts than those included in the repair kit are damaged.

**WARNING**
The enclosed section of the actuator is spring-loaded.
Installation dimensions

Quick release function: Actuation by impact of a blow on the flange

Thread of pipe connections: M16 x 1.5 - 16 deep
Installation instructions

The connecting lines must be installed in such a way as to permit problem-free bleeding. The actuator should be mounted at a slight angle, its piston rod pointing downwards.

Maintenance

Special maintenance that extends beyond the legally specified inspections is not required. When using high-pressure cleaners on the vehicle, please make sure that the water jet is not aimed directly at the spring brake actuator (damage to the bellows).

Repair work

CAUTION

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and pipes using appropriate plugs.
Purpose
The pressure switches are used to visually or audibly warn the driver of the pressure within the system.

Operation
Make contact / Circuit Closer
The pressure switch can be fitted in the brake line or directly on a braking device. The system pressure acts on an effective area within the switch, making an electrical contact as the pressure on that area is increased. The resulting current is used to activate a warning device for example.

Break contact / Circuit breaker
The pressure switch can be fitted in the brake line or directly on a braking device. The system pressure acts on an effective area within the switch, breaking an electrical contact as the pressure on that area is increased. The current flow is now interrupted, e.g. to deactivate a warning device.

Installation instructions
No special measures need to be taken.

Maintenance
Special maintenance that extends beyond the legally specified inspections is not required. When using high-pressure cleaners on the vehicle, please make sure that the water jet is not directed at the pressure switch (corrosion of the contacts).

Technical data

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Breaking capacity of all pressure switches 100 VA ohmic load protective cap for pressure switch:
Order number 897 750 342 4
Installation dimensions

![Diagram of installation dimensions with dimensions labeled: H1, H2, G, 13 ± 0.5, 0.8, 6.3 ± 0.1, SW 24.]

**Repair work**

**CAUTION**

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and pipes using appropriate plugs.

For safety reasons replace the complete pressure switch if damaged.

**Adjusting and testing the pressure switch**

The adjusting screw located between the two contact plugs can be adjusted to the customer-specific pressure within a certain range. The setting range is defined in the "Technical Data" table.

After making the adjustment, the adjusting screw should be secured using locking wax (or a similar locking material).
Hydraulic accumulator

Purpose

Fluids are practically incompressible and are thus incapable of accumulating pressure energy. In hydropneumatic accumulators, the compressibility of a gas is utilised to accumulate fluid. The compressible medium used in the accumulators is nitrogen.

In braking systems, the purpose of the accumulators is to store the energy supplied by the hydraulic pump. They are also used as an energy reserve when the pump is not working to compensate for any losses through leakage and for vibration damping.

Operation

The accumulator consists of a liquid part (A) and a gas part (B) with a diaphragm (C) as a gas-tight dividing element. The liquid part (A) is connected to the hydraulic circuit, causing the diaphragm accumulator to be filled and the gas volume to be compressed as the pressure rises. When the pressure falls, the compressed gas volume will expand, thus displacing the accumulated pressure fluid into the circuit.

The diaphragm bottom contains a valve disk (D) which, if the diaphragm accumulator is completely empty, closes the hydraulic outlet, thus preventing damage to the diaphragm.

Technical data

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<th>458 501 101 0</th>
<th>458 501 072 0</th>
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<td>Priming gas</td>
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Installation instructions

The accumulators can be fitted in the hydraulic circuit, directly on the component or in blocks on suitable consoles. They should be fitted in the coolest possible place. Any installation position can be chosen.

Maintenance of the device

Special maintenance that extends beyond the legally specified inspections is not required.

The accumulators should therefore be checked once every year. It should be replaced if the initial gas tension has fallen by more than 30% (see: Functional test and checking the accumulator).

Disposal of the accumulator

Before the accumulator is scrapped, its gas filling pressure must be released. For this purpose, drill a hole through the gas chamber (B) using a drill approx. 3 mm in diameter. The gas chamber is located on the side opposite the threaded port above the welding seam around the centre of the accumulator.

Wear safety goggles when carrying out this work.

Functional test and checking the accumulator

The accumulator is gradually pressurised via the test pump; until the initial gas pressure is reached, the hydraulic pressure in the accumulator will rise abruptly. This can be read off gauge "M". If the initial gas pressure is more than 30% below the prescribed value, the accumulator needs to be replaced. If the measuring process needs to be repeated, wait for intervals of 3 minutes between the individual tests.

An accumulator with insufficient gas initial tension must be scrapped following the instructions under "Disposal of the accumulator".

The initial gas pressure level can also be checked directly in the vehicle. Start the vehicle's engine. The pump will now supply oil to the accumulators. Until the initial gas pressure is reached, the hydraulic pressure in the accumulator will rise abruptly. This can be read off the gauge in the vehicle. If the initial gas pressure is more than 30% below the prescribed value, that initial pressure lies outside the permissible range for at least one of the accumulators fitted in the vehicle. This accumulator can only be determined using the testing method described above. In this case the accumulators must therefore be checked individually. The accumulator whose initial gas pressure is insufficient must be replaced and scrapped following the instructions under "Disposal of the Accumulator".

Repair work

CAUTION

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and on pipes using plugs.

For safety reasons replace the complete accumulator if it is damaged.
Purpose
The brake valve has the purpose of sensitively increasing and decreasing the braking pressure when the treadle (or the actuating lever) is operated.

Operation
Standby position
When the braking system is ready for operation, the accumulator pressure acts directly on port 1 of the brake valve. A connection is established between port 21 and port 51 so that the wheel brake (port 21) is switched pressureless via the return (port 51).

Partial braking
When the brake valve is actuated, a hydraulic braking pressure in proportion to the applied foot force is output.

The spring assembly (A) beneath the support (E) is designed in such a way that the braking pressure changes relative to the angle. In the lower braking pressure range the vehicle can be decelerated sensitively in stages.

When the braking process is initiated, the slide (C) is mechanically actuated via the spring assembly (A). As the slide (C) moves downward, it will first close the return 5 via the control edge, thus establishing a connection between accumulator port 1 and the wheel brake cylinder port 21. The foot force applied now determines the braking pressure to be applied. The control slide (C) is held in the control position by the force applied (spring assembly) and the hydraulic pressure below the slide (balance of forces). After output of the braking pressure, the slide (C) is in a partial braking position, causing ports 1 and 51 to close and maintaining the pressure in port 21.

Full braking position
When the pedal (B) is fully actuated, an end position of the brakes is reached and a connection established between accumulator port 1 and brake cylinder port 21. Return 51 is closed at this point.

When the braking process is terminated, a connection is once again established between brake cylinder port 21 and return port 51, closing accumulator port 1.

Limiting the braking pressure
The pedal stop screw (D) on the support (E) below the treadle (B) is used to limit the braking pressure. In this function only partial accumulator pressure is built up in the brake.
## Technical data

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<th>Order number</th>
<th>Slide Ø [mm]</th>
<th>Pedal angle [degrees]</th>
<th>Pedal force approx. [N]</th>
<th>Pedal via port</th>
<th>Operating pressure [bar]</th>
<th>Pressure limitation [bar]</th>
<th>Remark</th>
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</table>

Operating temperature range for all variants -30°C to +80°C

## Installation dimensions

Thread of pipe connections:
M 14x1.5 - 12 deep

Port designations:
1 = Energy supply
21 = Energy delivery
51 = Return connection

![Installation dimensions diagram](image-url)
Installation dimensions

shown: 467 406 102 0

Thread of pipe connections:

<table>
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<th>Variant</th>
<th>1, 21 and 51</th>
<th>24</th>
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<tr>
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<td>124</td>
<td>M 16x1.5 -12 deep</td>
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<td>121</td>
<td>M 16x1.5 -12 deep</td>
<td>M 10x1</td>
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</table>

Port designations:
1 = Energy supply
21 = Energy delivery
24 = Test port
51 = Return connection

Installation instructions

The return line 51 must be connected directly to the tank. The connecting lines must be installed in such a way as to permit problem-free bleeding.

**Maintenance of the device**
Special maintenance that extends beyond the legally specified inspections is not required.

When using high-pressure cleaners on the vehicle, please make sure that the water jet is not aimed directly at the foot brake valve (damage to the bellows).

**Replacing the pedal cover**
Pedal cover (1) is simply pulled off by hand. The new pedal cover is pushed over the treadle (B) and clamped manually. Fasten the bellows with the strap retainers.

**Replacing the complete actuating mechanism**
Carefully clamp the unit vertically in a fixture. The actuating mechanism can be removed by taking out the four screws (H) below the support (2). Make sure that the spring assembly (A) does not fall out. When installing the new actuating mechanism, make sure that the spring assembly (A) is fitted in the right order. Tighten the four screws (H).
Repair work

CAUTION

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and on pipes using plugs.

For safety reasons, replace the complete brake valve if other parts are damaged.
Purpose
The brake valve has the purpose of sensitively increasing and decreasing the braking pressure when the treadle (or the actuating lever) is operated.

Operation
Standby position
When the braking system is ready for operation, the accumulator pressure acts directly on port 1.1/1.2 of the foot brake valve. A connection is established between Ports 2.1/2.2 and Ports 5.1/5.2 so that the wheel brakes (Ports 2..) are pressureless via the returns (Ports 5..).

Partial braking
When the brake valve is actuated, a hydraulic braking pressure in proportion to the applied foot force is output. The spring assembly (A) beneath the support (E) is designed in such a way that the braking pressure changes relative to the angle. In the lower braking pressure range the vehicle can be decelerated sensitively in stages.

When the braking process is initiated, the upper slide (C1) is mechanically actuated via the spring assembly (A), and the lower slide (C2) is actuated hydraulically by slide (C1). As slides (C1 and C2) move downward they will first close the returns 5.1/5.2 via the control edges, thus establishing a connection between the accumulator ports 1.1/1.2 and ports 2.1/2.2 of the wheel brake cylinders. The foot force applied now determines the braking pressure output. The control slides (C1 and C2) are held in the control position by the applied foot force (spring assembly) above the slides and the hydraulic pressure below the slides (balance of forces). Once the initiated braking pressure is applied, slides (C1 and C2) are in a partial braking position, causing ports 1.1/1.2 and 5.1/5.2 to close, maintaining the pressure in ports 2.1/2.2.

Full braking position
When pedal (B) is fully actuated, an end position of the brakes is reached and a connection established between the accumulator ports 1.1/1.2 and brake cylinder ports 2.1/2.2. Returns 5.1/5.2 are closed at this point.

When the braking process ends, a connection is once again established between brake cylinder ports 2.1/2.2 and return ports 5.1/5.2, closing accumulator ports 1.1/1.2.

The arrangement of slides in the valve ensures that even if one braking circuit fails the other remains fully operational. This is achieved by means of the mechanical actuation of both slides and requires slightly more pedal travel.

Limiting the braking pressure
The pedal stop screw (D) on the support (E) below the treadle (B) is used to limit the braking pressure.

Failure of a circuit
In the event of the lower circuit failing, the upper circuit will remain operational. The spring assembly (A) will mechanically actuate the slide (C1). In the event of the upper circuit failing, the lower circuit will remain operational. In this case the lower slide (C2) is mechanically actuated by the spring assembly (A) and the slide (C1).

The return lines 5.1/5.2 must be connected directly to the tank. The connecting lines must be installed in such a way as to permit problem-free bleeding.
### Technical data

<table>
<thead>
<tr>
<th>Order number</th>
<th>Slide Ø [mm]</th>
<th>Pedal angle [degrees]</th>
<th>Pedal force approx. [N]</th>
<th>Pedal via port</th>
<th>Operating pressure [bar]</th>
<th>Pressure limitation [bar]</th>
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Operating temperature range for all variants: -30°C bis +80°C

### Spare parts

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<th>Designation</th>
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### Repair kits

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<td>467 406 007 2</td>
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</table>
Brake valve
for dual circuit braking systems

Installation dimensions

shown: 467 406 202 0

Port designations:
1.1, 1.2 = Hydraulic accumulator
2.1, 2.2 = Service brake
2.4, 2.5 = Test connection
5.1, 5.2 = Return connection

Thread of pipe connections:

<table>
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<tr>
<th>Variant</th>
<th>1.1, 1.2, 2.1, 2.2, 5.1, 5.2</th>
<th>2.4, 2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>208, 216, 218,</td>
<td>M 16x1.5 -12 deep</td>
<td>M 10x1 - 8 deep</td>
</tr>
<tr>
<td>220, 233, 234,</td>
<td></td>
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<tr>
<td>235, 510</td>
<td></td>
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</tr>
<tr>
<td>411, 413</td>
<td>M 16x1.5 -12 deep</td>
<td>M 12x1.5 - 8 deep</td>
</tr>
<tr>
<td>202, 301, 401,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>408, 414</td>
<td>M 16x1.5 -12 deep</td>
<td>M 12x1.5 - 10 deep</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

shown: 467 406 208 0
Installation dimensions

shown: 467 406 227 0

Port designations:
1.1, 1.2 = Hydraulic accumulator
2.1, 2.2 = Service brake
2.4, 2.5 = Test connection
5.1, 5.2 = Return connection

shown: 467 406 246 0
Installation instructions

Maintenance of the device
Special maintenance that extends beyond the legally specified inspections is not required. When using high-pressure cleaners on the vehicle, please make sure that the water jet is not aimed directly at the foot brake valve (damage to the bellows).

Replacing the pedal cover
Pedal cover (1) is simply pulled off by hand. The new pedal cover (1) is pushed over the treadle (B) and tightened manually. Fasten the bellows with the strap retainers.

Replacing the complete actuating mechanism
Carefully clamp the unit vertically in a fixture. The actuating mechanism can be removed by unscrewing the four screws (H) below the support (E). Make sure that the spring assembly (A) does not fall out. When installing the new actuating mechanism, make sure that the spring assembly (A) is fitted in the right order. Tighten the four screws (H).

Replacing the bellows
To change the bellows (3) it is advisable to remove the treadle (B). For this purpose, loosen the retaining ring (L) and knock out the bolt (M) using a mandril. When knocking out the bolt, make sure that the mandril is applied to the side of the bolt without knurls. Remove treadle (B) and bellows (3). Now fit the new bellows (3) and proceed as described above in reverse order. The upper section of the bellows (3) is fastened to piston (N), its lower portion to the support (E). Secure the bellows using clamps.

Replacing the lip seal
Carefully clamp the unit vertically in a fixture. Unscrew screw plug (P) and pull the slides (C1 and C2) out downwards. Check the slides for damage. If damage is identified, replace the complete foot brake valve (slide and housing are matched as pairs during production). If the slides are not damaged in any way, remove the whole actuating mechanism as described above. Remove the spring assembly (A) and lip seal (4) and put in a new pregreased lip seal with its lips pointing downwards. Re-insert the spring assembly as shown in the exploded view and install the complete treadle. Carefully re-insert the slide (C1) into the housing from below, turning it slightly. Insert the spring (R1), followed by the slide (C2), using a slight turning motion if possible. Insert the spring (R2) and close the unit with the screw plug (P). Check return port 5.1 to see if there is a gap of approx. 2 mm between the lower edge of the hole and the control edge of slide (C1). If this is not the case, change the setting by removing or adding distance washers (5) in the upper spring seat. Check the distance between the lower edge of the hole at port 5.1 and the control edge of slide (C1) again.

Repair work

![CAUTION](image)

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and on pipes using plugs.

For safety reasons, replace the complete brake valve if other parts are damaged.
Purpose
The brake valve has the purpose of sensitively increasing and decreasing the braking pressure when the treadle is operated. In addition there is the option to connect a further hydraulic actuation to port 3. This could be a single circuit brake valve, for example, to brake the vehicle in stages using the respectively other foot.

Operation
Actuation on port 3 causes pressure to be applied to the ring surface of the intermediate piston (A), which then operates the top slide (C1) via the spring assembly connected in series.

The subsequent mode of action is identical to that of a basic brake valve.

 Limiting the braking pressure

The ring nut (D) at the top end of the intermediate piston (A) is used to limit the braking pressure.
**Purpose**

The brake valve has the purpose of sensitively increasing and decreasing the braking pressure when the treadle is operated.

It is also equipped with a switch box containing up to 4 microswitches for stepped control of a retarder.

**Operation**

When the brake valve is actuated, the microswitches are operated one after the other by means of the intermediate piston. The retarder is controlled as required prior to or during the process of adjusting the hydraulic braking pressure.

The subsequent mode of action is identical to that of a basic brake valve.

---

**Technical data**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<td>14</td>
<td>35</td>
<td>400</td>
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<td>Retarder brake valve, 3 switches</td>
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<tr>
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<td>2</td>
<td>14</td>
<td>35</td>
<td>450</td>
<td>51</td>
<td>150</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>467 406 509 0</td>
<td>2</td>
<td>14</td>
<td>35</td>
<td>510</td>
<td>51</td>
<td>150</td>
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<tr>
<td>467 406 510 0</td>
<td>2</td>
<td>12</td>
<td>45</td>
<td>340</td>
<td>5</td>
<td>250</td>
<td>128+10</td>
<td>Retarder brake valve, 2 switches</td>
</tr>
<tr>
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<td>2</td>
<td>12</td>
<td>45</td>
<td>450</td>
<td>5</td>
<td>250</td>
<td>128+10</td>
<td></td>
</tr>
<tr>
<td>467 406 512 0</td>
<td>2</td>
<td>12</td>
<td>45</td>
<td>400</td>
<td>5</td>
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<td>167±5</td>
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**Spare parts**

<table>
<thead>
<tr>
<th>Order number</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>897 754 865 4</td>
<td>Bellows</td>
</tr>
</tbody>
</table>
**Purpose**

The purpose of the park brake valve is to sensitively increase and decrease the braking pressure when the park brake lever is operated.

**Operation**

**Standby position**

When the braking system is ready for operation, the accumulator pressure acts directly on port 1 of the park brake valve. A connection is established between port 1 and port 21 so that the vehicle's park brake is released.

**Secondary braking**

When the park brake valve is actuated, the hydraulic release pressure is increased or decreased in accordance with the park brake lever's pivoting angle. The spring assembly (A) below the cam (B) permits sensitive stepped braking of the vehicle.

When the secondary braking process is initiated, slide (C) is mechanically actuated via the spring assembly (A). The upward moving slide (C) first closes the accumulator port 1 via the control edge and then establishes a connection between the brake cylinder port 2 and return 5. The pivoting angle reached by the park brake lever will now determine the pressure in the spring brake actuator (port 2). The control slide (C) is held in the control position by the force of the spring assembly above the slide and by the hydraulic pressure below the slide (balance of forces). The slide (C) is in a partial braking position, causing ports 1 and 5 to close and to maintain the pressure in port 2.

Within partial braking range, the hand lever will automatically return to the driving position when the braking process is ended.

**Parking brake action**

When the lever is fully actuated, an end position of the brake is reached and a connection is established between return 5 and brake cylinder port 2. Accumulator port 1 is closed as a result, and the lever is locked in position. When parking brake action ends, the connection between brake cylinder port 2 and accumulator port 1 is re-established, and return port 5 is closed. Once released from its locked position, the park brake lever will automatically return to the driving position.

**Installation instructions**

The return line 5 must be connected directly to the tank. The connecting lines must be installed in such a way as to permit problem-free bleeding. The device should be installed in a position where it cannot be accidentally actuated by the driver's foot (floor of the vehicle).

**Maintenance of the device**

Special maintenance that extends beyond the legally specified inspections is not required.

When using high-pressure cleaners on the vehicle, please make sure that the water jet is not aimed directly at the park brake valve (damage to the bellows).

**Repair work**

**CAUTION**

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and on pipes using plugs.

For safety reasons, replace the complete brake valve if other parts are damaged.

**Replacing the bellows**

To remove and replace the bellows (D), the actuating button (E) needs to be removed from the lever (F). To do this, push out the two retaining pins (G). The bellows (D) can now be pulled off and the new one installed. Then push actuating button (E) back onto the lever (F) and secure it with the retaining pins (G).
Technical data

<table>
<thead>
<tr>
<th>Order number</th>
<th>Operating pressure</th>
<th>Working pressure</th>
<th>Permissible medium</th>
<th>Thermal range of application</th>
<th>in locked position</th>
</tr>
</thead>
<tbody>
<tr>
<td>467 410 011 0</td>
<td>150 bar</td>
<td>50 bar</td>
<td>Mineral oil</td>
<td>-40°C to +80°C</td>
<td>pressure reducing</td>
</tr>
<tr>
<td>467 410 012 0</td>
<td>125 bar</td>
<td>50 bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>467 410 015 0 *)</td>
<td></td>
<td>50 bar</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*) for replacement only

Spare parts

<table>
<thead>
<tr>
<th>Designation</th>
<th>Order number</th>
<th>Device variant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bellows</td>
<td>897 754 190 4</td>
<td>For all devices still in-use</td>
</tr>
</tbody>
</table>

Installation dimensions

shown: 467 410 012 0

Thread of pipe connections:
1,21, 5 = M16 x 1.5 - 10 deep
25 = M 12 x 1.5 -10 deep

Port designations:
1 = Energy supply
21 = Energy delivery
24 = Pressure switch connection
5 = Return connection
Purpose

The compact valve has the purpose of sensitively increasing and decreasing the braking pressure when the treadle is operated and to regulate the accumulators. The device is designed for use in load-sensing systems.

Operation

Standby position

The accumulator acts directly on the brake valve circuits 2.1/2.2. A connection is established between ports 6.1/6.2 and port 5 so that the wheel brakes are switched to zero pressure via the return.

Charging process

If the accumulator pressure drops to the defined value, the control slide (F) moves up and connects the load-sensing port 2 with the pump port 1 via the control edge. This causes the variable displacement pump to charge the accumulators with a defined volume flow. When the cut-off pressure is reached, the control slide (F) moves down and reconnects the load-sensing port with the return. The pump then only provides standby pressure.

Simultaneously switching off the pin (G) provides the switching hysteresis. The shuttle valve (H) causes the accumulator with the lowest pressure to assume the switching function of the cutoff valve while still continuing to protect the circuit in the event of a broken pipe.

Partial braking

When the brake valve is actuated, a hydraulic braking pressure in proportion to the applied foot force is output. The spring assembly (A) beneath the support (E) is designed in such a way that the braking pressure changes relative to the angle. In the lower braking pressure range the vehicle can be decelerated sensitively in stages. When the braking process is initiated, the upper slide (C1) is mechanically actuated by slide (C1). As slides (C1 and C2) move downward they will first close the returns 5 via the control edges and then establish a connection between the accumulator ports 2.1/2.2 and ports 6.1/6.2 of the wheel brake cylinders. The foot force applied now determines the braking pressure output. The control slides (C1 and C2) are held in the control position by the applied foot force (spring assembly) above the slides and the hydraulic pressure below the slides (balance of forces). Once the initiated braking pressure is applied, slides (C1 and C2) are in a partial braking position, causing ports 2.1/2.2 and 5 to close, maintaining the pressure in ports 6.1/6.2.

Full braking position

When pedal (B) is fully actuated, an end position of the brakes is reached and a connection established between the accumulator ports 2.1/2.2 and brake cylinder ports 6.1/6.2. Returns 5 are closed at this point. When the braking process ends, a connection is once again established between brake cylinder ports 6.1/6.2 and return port 5, closing accumulator ports 2.1/2.2. The arrangement of slides in the valve ensures that even if one braking circuit fails the other remains fully operational. This is achieved by means of the mechanical actuation of both slides and requires slightly more pedal travel.

Limiting the braking pressure

The pedal stop screw (D) on the support (E) below the treadle (B) is used to limit the braking pressure.

Failure of a circuit

In the event of the lower circuit failing, the upper circuit will remain operational. The spring assembly (A) will mechanically actuate the slide (C1). In the event of the upper circuit failing, the lower circuit will remain operational. In this case the lower slide (C2) is mechanically actuated by the spring assembly (A) and the slide (C1).

Repair kit 467 415 920 2
includes springs
Bellows 897 754 860 4
Purpose
The purpose of the cutoff valve is to control the pressure level in the accumulators.

Operation
Standby position
When the braking system is ready for operation (i.e. the accumulators are charged) the pump stream is applied on port 1 of the cutoff valve. A connection is established between port 1 and 5 so that the pump stream can, with a small difference in pressure, be returned directly to the reservoir or other consumers. The rear of the main slide (A) is pressureless. The pressure within the braking system will hold the control slide (B) in its locked position (E1) in which the rear of the main slide (A) is directly connected to return 5 via the hole (G).

The check valve (C) in the hole to port 2 secures the accumulator pressures.

Charging process
If the accumulator pressure falls to the predefined value, the control slide (B) will, through the force of the spring assembly (D), overcome its locked position (E1) and move to a new locked position (E2). An oil stream flows to the rear of the main slide (A) via the orifice (F) and through the connecting hole (H). The pressure building up at the rear of main slide (A) and the pressure present below the main slide (A) put the main slide (A) in a floating position, permitting a partial stream to continue to reach port 5 and the remaining stream to flow to port 2 via the check valve (C) until the pressure at port 2 is approx. 150 bar. The control slide (B) will then move back to the locked position (E1) in which a connection is established between port 1 and port 5, and the full pump flow is directed into the reservoir again. The check valve (C) secures the accumulator pressures again.

Technical data

<table>
<thead>
<tr>
<th>Order number</th>
<th>477 397 001 0</th>
<th>477 397 011 0</th>
<th>477 397 031 0</th>
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<tbody>
<tr>
<td>Operating pressure</td>
<td>max. 200 bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure at port 5</td>
<td>max. 200 bar</td>
<td>max. 200 bar</td>
<td>max. 50 bar</td>
</tr>
<tr>
<td>Cut-in pressure</td>
<td>120 +10 bar</td>
<td>120 +10 bar</td>
<td>120 +10 bar</td>
</tr>
<tr>
<td>Cut-off pressure</td>
<td>150 .10 bar</td>
<td>150 .10 bar</td>
<td></td>
</tr>
<tr>
<td>Flow rate</td>
<td>max. 16 l/min</td>
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<tr>
<td></td>
<td>from 1⇒ 2 = 2...0.3 l/min from 1⇒ 5 = 45 l/min</td>
<td>from 1⇒ 2 = 17...19 l/min from 1⇒ 5 = 45 l/min</td>
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<tr>
<td>Permissible medium</td>
<td>Mineral oil: 10 . . . 1,940 mm² /s</td>
<td></td>
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<tr>
<td>Thermal range of application</td>
<td>-30°C to +80°C</td>
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<tr>
<td>Weight</td>
<td>2.4 kg</td>
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</table>
Installation dimensions

shown: 477 397 001 0

Thread of pipe connections:
1, 5 = M 18 x 1.5 -14 deep (M = 50 ± 5 Nm)
2 = M 16 x 1.5 - 14 deep (M = 40 ± 5 Nm)

Port designations:
1 = Energy supply
2 = Service brake
5 = Return connection

Installation instructions

The connecting lines must be installed in such a way as to permit problem-free bleeding.

Maintenance of the device
Special maintenance that extends beyond the legally specified inspections is not required.

Repair work

CAUTION

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and on pipes using plugs.

For safety reasons replace the complete cutoff valve if it is damaged.
Purpose
The purpose of the cutoff valve is to control the pressure level in the accumulators.

Operation
Standby position
When the braking system is ready for operation (i.e. the accumulators are charged) the pump flow acts directly on port 1 of the cutoff valve. A connection is established between port 1 and port 5 so that the pump flow is, with a small difference in pressures, returned directly to the reservoir. The rear of the main slide (A) is pressureless.

The pressure within the braking system will hold the control slide (B) in its locked position (E1) in which the rear of the main slide (A) is directly connected to return 5 via the hole (G). The check valve (D) in the hole to ports 21 and 23 secures the accumulator pressures. The shuttle valve (H) causes the accumulator with the lowest pressure to operate the cutoff valve while continuing to protect the circuit in the event of a broken pipe.

Charging process
If the accumulator pressure falls to the predefined value, the control slide (B) will, through the force of the spring assembly (C), overcome its locked position (E1) and move to a new locked position (E2). An oil stream flows to the rear of the main slide (A) via the connecting hole (F). The pressure building up at the rear of the main slide and the pressure present below the main slide (A) put the main slide (A) in a floating position, permitting a partial flow to continue to reach port 5 and the remaining flow ports 21/23 via the check valve (D) until the pressure within the braking system is approx. 150 bar. The control slide (B) will then move to the locked position (E1) again, in which a connection is established between ports 1 and 5. The full pump flow is directed into the reservoir again via port 5. The check valve (D) secures the accumulator pressures again.

Technical data

<table>
<thead>
<tr>
<th>Order number</th>
<th>477 397 015 0</th>
<th>477 397 032 0</th>
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</thead>
<tbody>
<tr>
<td>Operating pressure</td>
<td>max. 200 bar</td>
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<tr>
<td>Pressure at port 5</td>
<td>200 bar for a short time</td>
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<tr>
<td>Cut-in pressure</td>
<td>120 +8 bar</td>
<td>70 +8 bar</td>
</tr>
<tr>
<td>Cut-off pressure</td>
<td>150 -8 bar</td>
<td>100 -8 bar</td>
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<tr>
<td>Rate of flow</td>
<td>max. 45 l/min</td>
<td>max. 62 l/min</td>
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<td>Permissible medium</td>
<td>Mineral oil: 2000 to 10 mm² /s</td>
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</tr>
<tr>
<td>Operating range</td>
<td>22 -8 bar</td>
<td></td>
</tr>
<tr>
<td>Thermal range of application</td>
<td>-30°C to +80°C</td>
<td></td>
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<tr>
<td>Weight</td>
<td>3.8 kg</td>
<td>4.1 kg</td>
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<tr>
<td>Flow rate to the braking circuits</td>
<td>3 +1 dm³/min</td>
<td>10...12 dm³/min</td>
</tr>
<tr>
<td>Pressure switch in port 28</td>
<td>No</td>
<td>Yes</td>
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</tbody>
</table>
Installation instructions

The connecting lines must be installed in such a way as to permit problem-free bleeding.

Maintenance of the device
Special maintenance that extends beyond the legally specified inspections is not required.

Repair work

CAUTION

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and pipes using plugs.

For safety reasons replace the complete cutoff valve if it is damaged.

Installation dimensions

Thread of pipe connections:
1, 5 = M18x1.5 -12 deep (M = 50 ± 5 Nm)
21, 23, 27 = M16x1.5 -12 deep (M = 40 ± 5 Nm)
28 = M12x1.5 -12 deep (M = 28 ± 3 Nm)

Port designations:
1 = Energy supply
21, 23 = Service brake
27 = Hydraulic accumulator
28 = Pressure switch
5 = Return connection
Purpose
The purpose of the cutoff valve is to control the pressure level in the accumulators.

Operation
Standby position
When the braking system is ready for operation (i.e. the accumulators are charged) the pump flow acts directly on port 1 of the cutoff valve. A connection is established between port 1 and port 5 so that the pump flow is, with a small difference in pressures, returned directly to the reservoir. The rear of the main slide (A) is pressureless. The pressure within the braking system will hold the control slide (B) in its locked position (E1) in which the rear of the main slide (A) is directly connected to return 5 via the hole (G). The check valve (D) in the hole to port 27 secures the accumulator pressure of the switching accumulator. The latter is available as an additional braking volume for the braking system, preventing excessively frequent actuation of the device in the event of a leakage. The check valves (H) additionally protect each braking circuit against pressure losses in the event of a broken pipe.

Charging process
If the accumulator pressure falls to the defined value, the control slide (B) will, through the force of the spring assembly (C), overcome its locked position (E1) and move to a new locked position (E2). An oil stream flows to the rear of the main slide (A) via the connecting hole (F). The pressure building up at the rear of the main slide (A) and the pressure present below the main slide (A) put main slide (A) in a floating position, permitting a partial flow to continue to reach port 5 and the remaining flow ports 21/22/23 via the check valve (D) until the pressure within the braking system is approx. 150 bar. The control slide (B) will then move to the locked position (E1) again, in which a connection is established between ports 1 and 5. The full pump flow is directed into the reservoir again via port 5. The check valve (D) secures the accumulator pressures again.
The connecting lines must be installed in such a way as to permit problem-free bleeding.

Maintenance of the device
Special maintenance that extends beyond the legally specified inspections is not required.

Repair work
CAUTION
When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and on pipes using plugs.

For safety reasons replace the complete cutoff valve if it is damaged.
**Check valve**

**Purpose**

The check valve has the purpose of ensuring that the pressure in the intact braking circuits of a triple circuit braking system is maintained in the event of one circuit failing.

**Operation**

**Filling Position**

After the check valves (A) have opened, the oil flow from port 1 will reach the downstream accumulators of the brake valves via ports 21 and 22 and the accumulator for the park brake valve via port 23. Pressure gauges or pressure switches can be connected at ports 24, 25 and 26 to check the braking pressure.

**Standby position**

When the pressure at port 1 is reduced, a return flow of the oil is prevented by closing of the check valves (A), thus securing the pressure in the hydraulic accumulators. When the pressure is increased, the check valves (A) are opened again to equalise the pressure between the circuits.

**Pressure limitation**

A pressure limiting valve (B) integrated in the check valve limits the output pressure to a maximum of 180 bar.

---

**Technical data**

<table>
<thead>
<tr>
<th></th>
<th>477 399 300 0</th>
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<tbody>
<tr>
<td>Order number</td>
<td>477 399 300 0</td>
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<tr>
<td>Operating pressure</td>
<td>max. 160 bar</td>
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<tr>
<td>Pressure limitation</td>
<td>180 *10 bar</td>
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<td>Permissible medium</td>
<td>Mineral oil: 1940 to 10 mm² /s</td>
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<td>Thermal range of application</td>
<td>-40°C to +80°C</td>
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<td>Flow rate</td>
<td>0.7 to 16 l/min</td>
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<tr>
<td>Nominal diameter</td>
<td>8 mm</td>
</tr>
</tbody>
</table>
Installation dimensions

Thread of pipe connections:
1, 5, 21 = M14x1.5 DIN 74 235
22, 23 = M14x1.5 -12 deep
24, 25
26

Port designations:
1 = Energy supply
21 – 26 = Energy delivery
5 = Return connection

Installation instructions

The connecting lines must be installed in such a way as to permit problem-free bleeding.
Any installation position can be chosen.

Maintenance of the device
Special maintenance that extends beyond the legally specified inspections is not required.

Repair work

CAUTION

When working on the braking system, always make sure that there is absolutely no pressure in the system.
Even when the engine is switched off there will be some residual pressure in the system.

When carrying out repair work, make sure your environment is absolutely clean.
Immediately close all open ports on the components and on pipes using plugs.

For safety reasons replace the complete triple-circle check valve if it is damaged.
Purpose
The relay valve has the purpose of transferring large volumes to the wheel brake within a short time. It offers the benefit of being able to be actuated with a small actuating volume.

Operation
Standby position
When the braking system is ready for operation, the accumulator pressure is present at port 1 of the relay valve. A connection is established between ports 2 and 5 so that the wheel brake cylinders of the vehicle are released.

Braking position
When the foot brake valve is actuated, a hydraulic braking pressure builds up at port 2 in proportion to the input pressure in port 4. When the braking process is initiated, the slide (A) is actuated via the control port 4 and moves into the braking position against the force of the spring (B). The slide will first close return port 5 via the control edge and then, via another control edge, connect accumulator port 1 with port 2. The oil now flows from port 1 to port 2 via a hole and the hollow slide (A), moving it to its final braking position. In this process, the output braking pressure at port 2 is equal to the control pressure of the foot brake valve at port 4.

Release position
If the control pressure at port 4 is reduced, the hollow slide (A) returns to its initial position. The connection from port 1 to 2 is closed again by the control edges. The second control edge will then open the connection between port 2 and return port 5.

Technical data

<table>
<thead>
<tr>
<th>Order number</th>
<th>477 411 000 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating pressure</td>
<td>max. 250 bar</td>
</tr>
<tr>
<td>Control volume</td>
<td>1.3 cm³</td>
</tr>
<tr>
<td>Pressure at port 5</td>
<td>&lt; 3 bar</td>
</tr>
<tr>
<td>Permissible medium</td>
<td>Mineral oil: 2000 to 10 mm² /s</td>
</tr>
<tr>
<td>Thermal range of application</td>
<td>-40°C to +80°C</td>
</tr>
<tr>
<td>Transmission ratio</td>
<td>1 : 1</td>
</tr>
</tbody>
</table>
Installation instructions

The return line must be connected directly to the tank.
The connecting lines must be installed in such a way as to permit problem-free bleeding.
The relay valve should be mounted in the vicinity of the wheel brake.

Maintenance of the device
Special maintenance that extends beyond the legally specified inspections is not required.

Repair work

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.</td>
</tr>
<tr>
<td>When carrying out repair work, make sure your environment is absolutely clean. Immediately close all open ports on the components and on pipes using plugs.</td>
</tr>
<tr>
<td>For safety reasons replace the complete relay valve if it is damaged.</td>
</tr>
</tbody>
</table>
Appendix
a) All pipes in the braking system must have a nominal width of at least 10 mm.

b) The pipes should be installed in such a way as to permit problem-free bleeding, i.e. so that no air cushions can develop. If you detect noises when applying the brake, this is an indication of poor bleeding.

c) When fitting the pipes, make sure that no areas of friction can develop.

d) The return lines of the individual components of the braking system must not be combined in one return line to the tank.

e) The return lines of the dual-circuit foot brake valve must not be designed as a pipe and combined into a single return line. This is possible only if ports 5.1 and 5.2 are connected by means of hoses and combined to form one return line.

f) Look for visible leaks in lines and pipes. Leaks are an indication that the system is not properly sealed. Check the level of the brake fluid. Eliminate the leaks.

g) When using high-pressure cleaners, do not aim the nozzle directly at the bellows (possible damage to the bellows).

h) When working on the braking system, always make sure that there is absolutely no pressure in the system.

i) Make sure your environment is absolutely clean.

j) Immediately close all open ports on the components and on pipes using plugs.

**CAUTION**

Even when the engine is switched off or with the pump not running the system pressure will be maintained in the system.
Installation instructions

It is particularly important that the components all have their separate return lines, otherwise the return pressure can be present in the wheel brake in the form of residual pressure. This leads to unnecessary wear of the brake linings and excessive temperatures at the wheel brake and can thus result in hardening of the linings and in a failure of the seals on the wheel brake cylinders.

When combining the returns of the dual circuit foot brake valve, please make sure that hoses are used for connecting the return ports. Using a pipe to connect the two circuits can result in impaired functions due to distortions during installation.

For very long vehicles with large cylinder volumes, the installation of relay valves can be very helpful, reducing response and pressure build-up times to a minimum. The relay valve should be fitted as close to the wheel brake cylinders as possible. The lengths of the lines from the accumulator to the wheel brake cylinders are thereby reduced because the foot brake valve only actuates the relay valves. The input volume of the relay valves is approx. 1 cm³.

If cutoff valves with an integrated check valve are used, an additional accumulator of 0.7 litres needs to be screwed into the component. That additional accumulator is primarily used to monitor the actual pressure of the other three accumulators and pass them on to the control piston of the cutoff valve. The accumulators can be drained when the brakes are operated without being recharged since all circuits are protected against one another by the check valves. The additional accumulator will also prevent activation of the cutoff valve in the connection between the check valves in the event of minor leaks and associated pressure drops even though the pressure in the accumulators of the braking circuit is still higher than 120 bar.

Capacity of accumulators

The hydraulic accumulators must be specially designed to comply with the legal provisions for the FPB with regard to the size of energy accumulators.

We support our customers, free of charge, in identifying the appropriate accumulator layout and capacity.
Application Data Sheet
for Hydraulic Full Power Brake Systems

Name ___________________________ Title ___________________________

Company ___________________________ Address ___________________________

Address ___________________________ Country ___________________________

Email ___________________________ Phone ___________________________

Vehicle Specification

Type of vehicle ___________________________ Name and model number ___________________________

Estimated annual production volume min. ______ max. ______

Gross vehicle weight kg ______ Empty vehicle weight kg ______ Wheel base m ______

Maximum speed k.p.h ______

Countries of use ___________________________

Braking standards and regulations ___________________________

Hydraulic Brake Specification

Service Brake [ ] Single-circuit [ ] Dual-circuit

Service brake pressure bar max. ______ Auxiliary brake pressure bar min. ______

Parking Brake

[ ] No

[ ] Yes SAHR type [ ] No

Parking brake pressure bar min. ______ max. ______

[ ] Yes

Release pressure bar min. ______ max. ______

Pushrod force N min. ______ max. ______

Pump flow l/min min. ______ max. ______ Pump pressure bar max. ______

Operating temperature °C min. ______ average ______ max. ______

System fluid used ___________________________ Fluid manufacturer and brand name ___________________________

Wheel brake type ___________________________ Wheel brake manufacturer ___________________________

Wheel brake consumption volume per circuit cm³ max. ______ min. ______

Parking brake type ___________________________ Parking brake manufacturer ___________________________

Parking brake consumption volume cm³ max. ______ min. ______
Hydraulic Braking Systems with Stored Energy

1. CAPACITY OF ENERGY STORAGE DEVICES (ENERGY ACCUMULATORS)

1.1. General

1.1.1. Vehicles whose braking system requires the use of stored energy provided by hydraulic fluid under pressure must be equipped with energy storage devices (energy accumulators) of a capacity meeting the requirements of paragraph 1.2 of this annex (part C).

1.1.2. However, the energy storage devices shall not be required to be of a prescribed capacity if the braking system is such that in the absence of any energy reserve it is possible with the service braking system control to achieve a braking performance at least equal to that prescribed for the secondary braking system.

1.1.3. In verifying compliance with the requirements of paragraphs 1.2.1., 1.2.2. and 2.1. of this annex, the brakes shall be adjusted as closely as possible and, for paragraph 1.2.1., the rate of full-stroke actuations must be such as to provide an interval of at least 60 seconds between each actuation.

1.2. Power-driven vehicles

1.2.1. Power-driven vehicles equipped with a hydraulic braking system with stored energy shall meet the following requirements:

1.2.1.1. After eight full-stroke actuations of the service braking system control, it shall still be possible to achieve, on the ninth application, the performance prescribed for the secondary braking system.

1.2.1.2. Testing shall be performed in conformity with the following requirements:

1.2.1.2.1. Testing shall commence at a pressure that may be specified by the manufacturer but is not higher than the cut-in pressure.

1.2.1.2.2. The energy storage device(s) shall not be fed; in addition, any energy storage device(s) for auxiliary equipment shall be isolated.

1.2.2. Power-driven vehicles equipped with a hydraulic braking system with stored energy which cannot meet the requirements of paragraph 2.2.1.5.1. of this Regulation shall be deemed to satisfy that paragraph if the following requirements are met:

1.2.2.1. After any single transmission failure it shall still be possible after eight full-stroke actuations of the service braking system control, to achieve, at the ninth application, at least the performance prescribed for the secondary braking system or, where secondary performance requiring the use of stored energy is achieved by a separate control, it shall still be possible after eight full-stroke actuations to achieve, at the ninth application, the residual performance prescribed in paragraph 2.2.1.4. of this Regulation.

1.2.2.2. Testing shall be performed in conformity with the following requirements:

1.2.2.2.1. With the energy source stationary or operating at a speed corresponding to the engine idling speed, any transmission failure may be induced. Before inducing such a failure, the energy storage device(s) shall be at a pressure that may be specified by the manufacturer but not exceeding the cut-in pressure.
1.2.2.2. The auxiliary equipment and its energy storage devices, if any, shall be isolated.

2. CAPACITY OF HYDRAULIC FLUID ENERGY SOURCES

2.1. The energy sources shall meet the requirements set out in the following paragraphs:

2.1.1. Definition of terms

2.1.1.1. "p₁" represents the maximum system operational pressure (cut-out pressure) in the energy storage device(s) specified by the manufacturer.

2.1.1.2. "p₂" represents the pressure after four full-stroke actuations with the service brake control, starting at "p₁" without having fed the energy storage device(s).

2.1.1.3. "t" represents the time required for the pressure to rise from p₂ to p₁ in the energy storage device(s) without application of the service braking system control.

2.1.2. Measurement conditions

2.1.2.1. During the test to determine the time t, the feed rate of the energy source shall be that obtained when the engine is running at the speed corresponding to its maximum power or at the speed allowed by the over-speed governor.

2.1.2.2. During the test to determine the time t, energy storage device(s) for auxiliary equipment shall not be isolated other than automatically.

2.1.3. Interpretation of results

2.1.3.1. In the case of all vehicles except those of categories M₃, N₂ and N₃ the time t shall not exceed 20 seconds.

2.1.3.2. In the case of vehicles of categories M₃, N₂ and N₃ the time t shall not exceed 30 seconds.

3. CHARACTERISTICS OF WARNING DEVICES

With the engine stationary and commencing at a pressure that may be specified by the manufacturer but does not exceed the cut-in pressure, the warning device shall not operate following two full-stroke actuations of the service braking system control.

Other national regulations must be observed if the vehicle is exported.
Further references

[12] ECE R-13 Rev 1, Add 12, Rev 5 – Annex 18, Special Requirements to be applied to the safety aspects of complex electronic vehicle control systems
Testing the WABCO Full Hydraulic Power Brake System (FPB) (after initial installation in the vehicle)

The legal requirements (abbreviated as "LR" below) listed below match the EC Directive 98/12/EC (consolidated version of Directive 71/320/EEC) and can be looked up in the WABCO paperback "Legal Requirements 2000".

A. Functional check of the hydraulic accumulators

1. With the engine turned off, depressurise the braking system by repeated full depression of the foot brake valve (around 30 - 40 times).

The pressure gauge in the driver's cab indicates 0 bar. The warning lamp in the driver's cab is lit.

2. Start the engine and leave idling.

3. The gauge pressure increases rapidly up to the minimum pressure with which one of the available hydraulic accumulator is pre-charged with nitrogen (priming pressure). Then the pressure increases more slowly.

If the pre-charge is lower than 40 bar, at least one hydraulic accumulator is defective. This accumulator must be identified and replaced. This can only be done by removing testing the units outside the vehicle. (Please note the disposal instructions on page 19).

Possible WABCO accumulators: 458 501 071 0; 458 501 101 0

LR: Annex IV, Section C, Paragraph 1.1 to 1.1.3. page 86/87

B. Functional check of the warning system

1. Testing at which pressure the warning lamp (warning system) goes out.

The warning lamp must go out at 90 +10 bar *).

*) with WABCO pressure switch: 441 014 049 0

2. Testing at which pressure the warning lamp (warning system) lights up. With the engine idling, use the foot brake valve to reduce the system pressure to approx. 120 bar cut-in pressure of the corresponding cutoff valve. Then carry out two full braking actions.

The warning lamp must not light after the second full braking action.

LR: Annex IV, Section C, Paragraph 3, page 88

C. Functional check of the cutoff valve

1. Check if maximum system pressure is reached.

The system pressure must be reached at 150 -10 bar.

2. With the engine idling, use the foot brake valve to reduce the system pressure to approx. 120 bar (cut-in pressure of the cutoff valve). The carry out 8 full braking actions. At the 9th full braking application it must be possible to achieve the (residual) braking effect prescribed for the secondary braking system.

LR:
Annex II, Paragraph 2.1.4. , page 52
Annex IV, Section C, Paragraph 1.2.1.1., page 87
Annex IV, Section C, Paragraph 1.2.1.2.1., page 87
Annex IV, Section C, Paragraph 1.2.1.2.2., page 87
Testing the WABCO Full Hydraulic Power Brake System

The pressure gauge indication may drop to a value of 50 bar (accumulator priming pressure) after nine brake applications.

3. Start the engine.

The maximum system pressure must now increase to 150 -10 bar again.

Possible WABCO cutoff valves:
477 397 001 0
477 397 007 0
477 397 011 0
477 397 014 0
477 397 015 0
477 397 031 0

4. Test if the cutoff valve switches to idle circulation once the system pressure is reached.

Install a measurement point on port 1 of the cutoff valve (tee). Check the commencing pressure drop using a connected pressure gauge.

5. At the same time, check if any double switch actions occur in the cutoff valve. These are also indicated on the pressure gauge (port 1 of the cutoff valve).

One possible reason for any double switching actions may be that the energy source (accumulator) was installed too far away from the cutoff valve (to optimise the line layout) or that the switch accumulator is defective (also refer to item "A").

6. Check for interior leaks in the cutoff valve.
With the 'engine idling', the brake not applied and maximum system pressure having been reached, the system pressure must drop below the cut-in pressure of the cutoff valve within four to six minutes.

For this test step the working medium (oil) must have been brought to operating temperature, i.e. the test must not be carried out with the braking system being in a cold state.

D. Functional test of the parking brake

1. Testing the indicator lamp during pressure reduction (initiation of braking)
At 21 +/-2 bar the park brake indicator lamp must light up.
Possible WABCO pressure switch: 441 014 043 0

2. Testing the pressure reduction and build-up by operating the park brake lever.
It must be possible to sensitively step the pressure.

3. Testing the indicator lamp during pressure reduction (releasing the park brake)
When the park brake is released, the indicator lamp must go out at approx. 23 bar.

4. Testing if the maximum system pressure is reached in the park brake circuit.
The maximum system pressure in accordance with the outline drawing for the installed park brake valve must be reached.
Possible WABCO park brake valves:
467 410 011 0; working pressure 50 bar
467 410 012 0; working pressure 125 bar
467 410 013 0; working pressure 125 bar
467 410 015 0; working pressure 50 bar
467 410 016 0; working pressure 100 bar
467 410 017 0, working pressure 50 bar
467 410 018 0, working pressure 60 bar

E. Functional test of the energy source (pump output)

1. Switch off the engine.

2. With the engine idling, use the foot brake valve to reduce the system pressure to 120 bar (cut-in pressure of the cutoff valve). Then fully apply the brake four times.

3. Start the engine.

At least 120 bar must be reached again within 30 seconds.

LR: Annex IV, Section C, Paragraph 2.1.3.2., page 88

General information

a) All pipes in the braking system must have a nominal width of at least 10 mm.

b) The pipes must be installed in such a way as to permit problem-free bleeding, i.e. so that no air cushions can develop. Pump noises when applying the brake generally indicate poor bleeding.

c) Check for visible leaks in lines and pipes. Leaks must be eliminated immediately (system pressure protection, protection of the environment). Frequent switching of the cutoff valve generally indicates leaks in the system.

d) When using high-pressure cleaners, do not aim the nozzle directly at the devices (possible damage to the bellows).

e) When working on the braking system, always make sure that there is absolutely no pressure in the system.

f) Make sure your environment is absolutely clean.

g) Immediately seal all open ports on the components and on pipes using plug.

CAUTION

Even when the engine is switched off or with the pump not running there will be some residual pressure in the system.

Before starting work on the system make sure that the system pressure was reduced to 0 bar (is achieved by fully pressing down the foot brake valve several times [up to 40 times]).
Possible WABCO park brake valves:
467.410.011 0; working pressure 50 bar
467.410.012 0; working pressure 125 bar
467.410.013 0; working pressure 125 bar
467.410.015 0; working pressure 50 bar
467.410.016 0; working pressure 100 bar
467.410.017 0, working pressure 50 bar
467.410.018 0, working pressure 60 bar

E. Functional test of the energy source (pump output)

1. Switch off the engine.

2. With the engine idling, use the foot brake valve to reduce the system pressure to 120 bar (cut-in pressure of the cutoff valve). Then fully apply the brake four times.

3. Start the engine.

At least 120 bar must be reached again within 30 seconds.

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WABCO (NYSE: WBC) is a leading global supplier of technologies and control systems for the safety and efficiency of commercial vehicles. Founded nearly 150 years ago, WABCO continues to pioneer breakthrough electronic, mechanical and mechatronic technologies for braking, stability and transmission automation systems supplied to the world’s leading commercial truck, bus and trailer manufacturers. With sales of $2.5 billion in 2012, WABCO is headquartered in Brussels, Belgium. For more information, visit www.wabco-auto.com