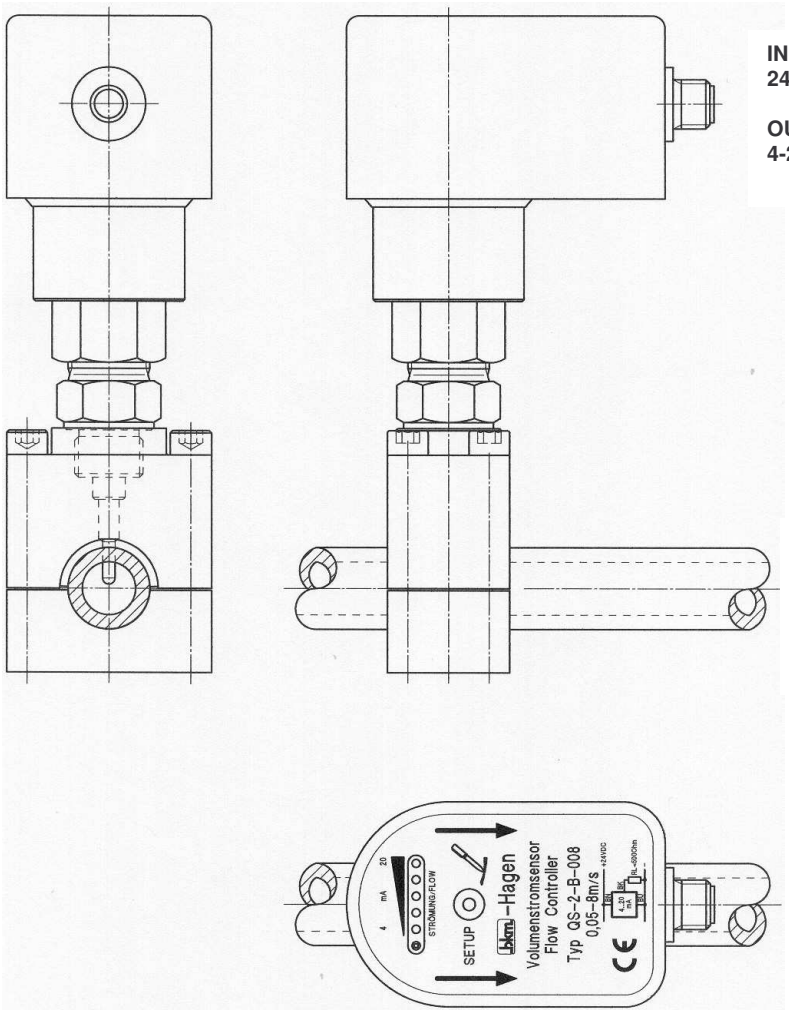
QS-2-B Flow Rate Sensor

Operation and use in combination with *serv-Clip*® measuring connector

Application examples for hydraulic and gear lubrication oils

A comprehensive range of new options for operating and monitoring plants



IN
24V DC; 150 AC

OUT
4-20 mA

Pipe
Ø12-42mm

0.05-8 m/s
0.15-800 l/min

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The flow rate sensor QS-2-B opens up new possibilities of operating and maintaining hydraulic plants.

Pumps
Pumping capacity; leakage caused by wear

Cylinders
Moving speed, sealing damages

Motors
Speed, leakage

Pressure accumulators
Charging function, bladders, seals

Oil coolers
Flow of hydraulic oil and cooling water

Valves
Flow, flow dividers, monitoring of operability

Aggregates
Volume demand adaptation

Safety Note:

Please read the installation and safety instructions in chapter 1.1 and 1.2 before installation!

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1 Read first

1.1 Installation instructions

Carefully read the installation instructions before installing *serv-Clip* ®.

After the *serv-Clip* ® pipe measuring connector has been mounted onto the pipe, the flow rate sensor is screwed into the former.

Make sure that you do not experience any major mechanical resistance until the sensor is completely screwed into the pipe. Should this be the case, the opening created in the pipe wall might not be big enough.

Make sure you used the correct needle (diameter: 3.3 mm) and screwed it down completely.

Do not use force to adjust the position of the housing. Always loosen the swivel nut before.

Tighten the swivel nut after you have adjusted the position of the sensor.

Do not forget to observe the regulations for electrical connections.

1.2 Safety

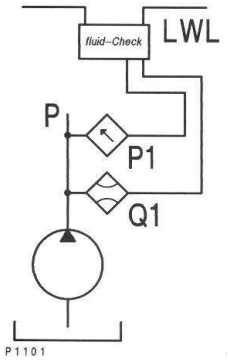
The sensor may only be installed and removed when the plant is in the non-pressurized condition.
After removing the sensor, the connection must be sealed either by means of the measuring connector or using a R $^{3}/_{8}$ DIN908 screw plug.

2. Which purposes has the flow rate sensor been developed for?

2.1 Reliable and fast flow rate monitoring without requiring extensive installation efforts and costs

The flow rate sensor QS-2-B was developed to provide a fast and cheap method to determine if, when, and how much hydraulic oil or water flows.
It replaces traditional measurement methods with a future-oriented system without mechanically moved parts.
To be competitive and maintain a market leading position, a supplier of sensors must be responsive and provide high-quality sensors that are affordable and easy to install.
The new flow rate sensor from BKM-Hagen fully meets these requirements.

2.2Application Examples



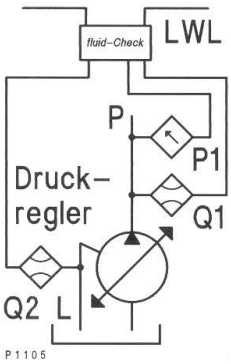
Fixed displacement pump

P_1 Operating pressure

Q_1 Flow rate

Functional check:

Pumping capacity and operating pressure



Pump with controlled pressure

P_1 Operating pressure

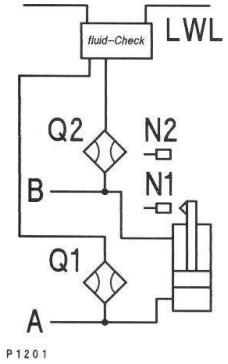
Q_1 Flow rate

Q_2 Flow of leak oil

Functional check:

Flow rate depending on operating pressure

Leak oil caused by pump wear



Differential cylinder

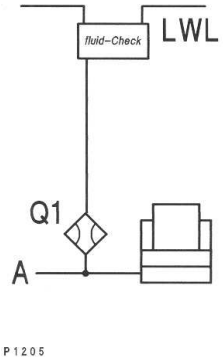
Q_1 Flow rate

Q_2 Flow rate

Functional check:

Moving speed

Sealing damages of piston and rod



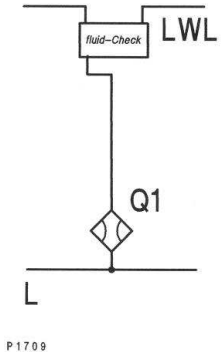
Plunger cylinder

Q_1 Flow rate

Functional check:

Flow rate

Piston seals

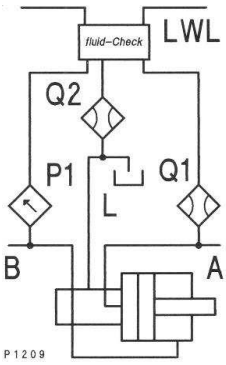


Leak oil line

Q_1 Flow rate

Functional check:

Increased flow of leak oil



Differential cylinder with rotating oil supply

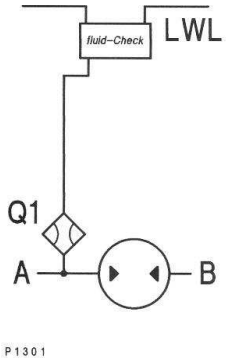
Q_1 Flow rate

Q_2 Flow rate

P_1 Operating pressure

Functional check:

Monitoring of cylinder seals and oil supply

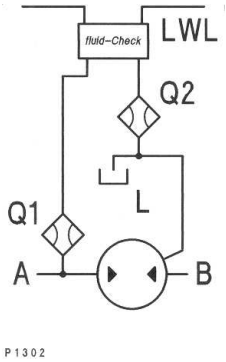


Oil motor

Q_1 Flow rate

Functional check:

Monitoring of speed



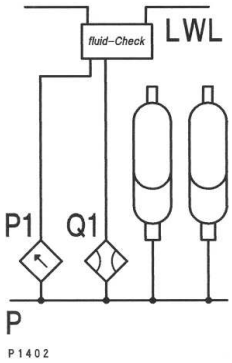
Oil motor

Q_1 Flow rate

Q_2 Flow rate

Functional check:

Monitoring of speed and wear of motor



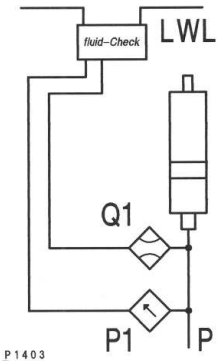
Bladder-type accumulator

Q_1 Flow rate

P_1 Operating pressure

Functional check:

Reduced storage capacity due to loss of gas or defective bladder



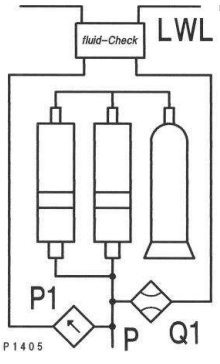
Piston accumulator

Q_1 Flow rate

P_1 Operating pressure

Functional check:

Reduced storage capacity due to loss of gas or wear of piston



Piston accumulator

Q_1 Flow rate

P_1 Operating pressure

Functional check:

Reduced storage capacity due to loss of gas, wear of piston or damaged seals

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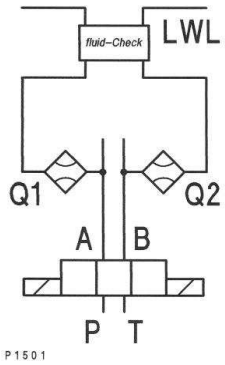


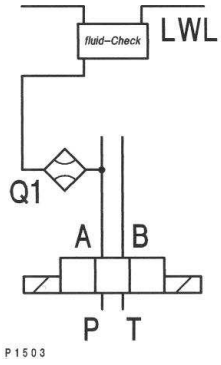
4/3-way valve

Q_1 Flow rate

Q_2 Flow rate

Functional check:

Operability of valve, percentage of leak oil, moving speed

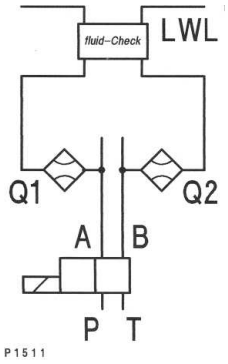


4/3-way valve

Q_1 Flow rate

Functional check:

Operability of valve, moving speed or number of revolutions



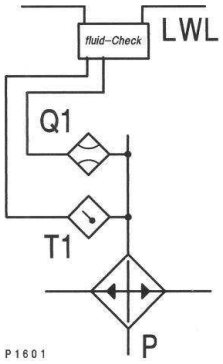
4/2-way valve

Q_1 Flow rate

Q_2 Flow rate

Functional check:

Operability of valve, percentage of leak oil, moving speed



Heat exchanger

Q_1 Flow rate

T_1 Operating temperature

Functional check:

Cooling of fluid, intrusion of oil and water

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3 Capabilities and benefits of the flow rate sensor QS-2 (0.15 – 800 l/min.)

3.1 Cost efficiency

Combined with the pipe measuring connector *serv-Clip*® SC-2, the flow rate sensor QS-2 provides an extremely convenient way of conducting measurements.
It is easily and quickly installed, reduces downtimes to a minimum, and is immediately ready for use.

3.2 Overview: Technical data

The flow rate sensor QS-2 provides many possibilities:

Takes only 3 minutes to install
Minimum space requirement: 30 mm
All common pipe diameters: 12 – 42 mm, imperial dimensions, R-Inches or even >42mm, including connecting piece for welding in place
Measuring range: 0.05 – 8 m/sec.; 0.15 – 800 l/min.
Operating range: 0.50 – 6 m/sec.
Connection of manual gauges, PLC, displays; 4 – 20 mA
Power supply 24 V DC +/- 10 %; 150 mA

3.3 Fields of application: Examples

Pumps Pumping capacity; Leakage caused by wear
Cylinders Moving speed, sealing damages
Oil motors Speed, leakage
Hydro-pneumatic accumulators Charging functions; bladders and seals
Oil coolers Flow of hydraulic oil and cooling water
Valves Flow division, monitoring of operability
Aggregates Monitoring of volume demand adaptation

3.4 The main benefits of the flow rate sensor QS-2

Reliable design, no wearing components
Can easily be replaced by screwed couplings, temperature sensors, etc.
Requires minimal time to install and remove
Very low flow resistance Δp
Very wide range of flow rates

4 Functional description: This is how the flow rate sensor QS-2-B works:

4.1 By which means does the sensor capture the flow rate?

When the sensor head is placed into the the fluid, a built-in heating element heats the sensor head to a temperature slightly above the ambient temperature.

An integrated thermo-couple measures the temperature inside the sensor head.

The flow velocity of the fluid is measured by heating the sensor head at very short time intervals and subsequently measuring the different cooling times.

As the sensor head is very small and thus has only little mass to be heated, the frequency of heating and measuring can be very high, which in turn also allows very short measuring cycles.

Depending on its heat absorption capability, the fluid used can affect the potential measuring range. In case of hydraulic oil or standard gear oils, the flow rate for measurements can be twice as high as that of water or aqueous emulsions. In general, this sensor is suitable for these types of liquid. If you wish to use other fluids or to determine the measuring range for liquids of higher viscosity, please contact us for further details.

4.2 Capturing range and pipe diameter

The sensor generates an analogue output signal in the range between 4 and 20 mA.

It captures flow rates from 0.08 to 8 m/sec. (when used with hydraulic oil) and from 0.05 to 4 m/sec. (when used with water or aqeous emulsions).

The flow rate sensor QS-2-B is rated for outer pipe diamaters of 12 x 1 to 42 x 5 mm or corresponding imperial and R-inch dimensions.

It is preferably to be installed in combination with the measuring connector *serv-Clip* ® SC-2-... or using the welded connecting pieces for pipe diameters > 42mm.

4.3 Output signal range

Basically, the flow rate sensor QS-2 supports all pipe diameters and flow rates within the specified ranges.

The output signal range can be set to the actual velocity or flow rate in the pipe.
For example, a flow rate of 2.5 – 250 l/min. can be matched to an output signal of 4 – 20 mA.

4.4 Output signals for parts of the flow rate

It is also possible to use one and the same sensor to measure only a small partial flow rate, for example, in order to determine whether an actuating cylinder is developing a sealing damage. To do so, the sensor can, for example, be set to 0.2 – 20 l/min., which would correspond to 4 – 20 mA. To achieve this, you can use a spread analogue signal in the upper or lower flow rate measuring range.

4.5 Default flow rate ranges (factory setting)

The flow rate sensor QS-2 is generally preset to a default range of 0.08 – 8 m/s.
This setting makes it possible to precisely display, for example, pump flow rates for a given pipe ID.
The flow rate sensor QS-2-B-008 is preset to 0.08 – 8 m/s. for pipe IDs between 10 and 38 mm with an output signal between 4 and 20 mA.

4.6 Determining the inner pipe diameter

Should the inner diameter of the pipe be unknown, it can easily be determined through the hole created in the pipe after the measuring connector *serv-Clip*®SC-2 has been installed. (See section 6.1 for the method used to determine the pipe ID).

4.7 Flow rate measuring and display units

Pumps, for example, can be monitored using a hand held measuring device or a programmable display unit.
You only have to complete the formula specified by entering the pipe ID with the measured current to obtain the flow rate in l/min.
To obtain precise measurements, the temperature of the fluid should always be the same, with the flow rate sensor QS-2 being set to the default values.

4.8 Evaluation of output signals in l/min

How is the flow rate calculated?
Example: Flow rate of a hydraulic pump

Hydraulic pipe, P-line: 38 x 4 mm, DI = 30 mm

Flow rate sensor: QS-2-B-008

(preset to 0.8 – 8 m/s.)

Pipe ID: d = 30 mm

Fixed value for hydraulic oil: V_x = 0,03

Correction value for current: A_x = mA – 4

Measured current

(Correction value) at output QS-2: 14,6 mA; -4 = 10,6 A_x

Flow rate: $\frac{d^2 \cdot \pi}{4} \cdot V_x A_x$ = l/min.

$$\frac{30^2 \cdot 3{,}14}{4} \cdot 0.03 \cdot 10.6 = 224\, l / \min.$$

Result: Flow rate of the pump during measurement = 224 l/min.

4.9 Evaluation of the output signal in mA

To monitor equipment such as pumps, hydraulic oil motors, cylinders, it is usually sufficient to evaluate the flow rate in mA. Through the measurements, any deviations are immediately detected.
In case of activated monitoring systems, corresponding messages can immediately forwarded be to remedy any problems.
Tolerance of such evaluations is less than ± 3%.

4.10 Evaluation by means of display units or fluid-Check ®

There are various ways to use the analogue output signal of 4 – 20 mA.

1. Use of a simple display unit
   In this case, the electric current corresponding to the measured flow rate is displayed in mA.
   Any changes become immediately visible.
2. Display units with comprehensive functionalities
   These devices are capable of displaying mA signals as a percentage or in any other form of scale.
   In addition, it is possible to store minimum and maximum values or to set switching values.
   For example, this provides a convenient way of switching pumps on and off, checking flow rates and switching signals.
3. Using a hand held measuring device, you can cheaply monitor even complex plants
   Using the measuring connectors SC-2, the sensors QS-2-B are mounted onto the pipes.
   In case of service and maintenance work, the different functions can then easily be checked.
4. All functions as described in section 2 can be used with your own programmable controller
   This makes it possible, for example, to display the individual measurements of the sensors on a VDU and to manage the evaluation using function keys.
5. With *fluid-Check*®, BKM's diagnostic system for plants and machinery, you can use a very convenient monitoring system which is completely independent of the electrical system of the plant
   This makes it possible to monitor almost all functions of hydraulic systems as well as gear lubrication systems, cooling systems with oil, water or aqueous emulsions as well as other electrical signals.
   fluid-Check® is very user-friendly and requires no programming skills to complete the installation.
   Please order our comprehensive information materials and contact us for advice.

5 Rating the flow rate sensor QS-2-B for the corresponding pipe ID

5.1 How is the flow rate calculated per mA?

The sensor QS-2-B-008 comes preset for flow rates of up to 8 m/sec. (hydraulic oil), independent of the corresponding pipe ID.

The sensor's output current is always between 4 – 20 mA.

The following method is used to determine the flow rate per mA.

Requirements: Sensor is preset to 8 m/sec. at 20mA, medium: hydraulic oil

Measuring range in mA $20 - 4 = \underline{16mA}$

Measuring range per mA $\frac{8\,m/\sec.}{16mA} = \frac{0{,}5m/\sec.}{mA}$

This corresponds to 0.5 m/sek. per mA

At a maximum, the sensor can thus measure a hydraulic oil flow rate of 480 m/min. at 8 m/sec.

To achieve precise measurements in l/min, the sensors should be preset to the given pipe ID.

Example:

Determining the existing flow rate.

Displayed value: 12mA

Sensor preset to 8m/sec. at 20mA

5.2 Formula to determine the maximum oil flow rate for a given pipe ID (in mm)

Example:

Flow rate max.	V_{max}=480 m/min (Oil)
Pipe ID	D_i = 10 mm
Max. output current	20 mA

$$V_x = \frac{480}{100016} = 0.03/\text{mA Hydraulic oil}$$

$$V_x = \frac{240}{100016} = 0.015/mA\ \ Water$$

$$A_x = \text{Output} - 4$$

$$\frac{d^2 \cdot \pi}{4} \cdot V_x \cdot \text{A}_\text{x} = l/\min.$$

$$\frac{10^2 \cdot 3{,}14}{4} \cdot 0.03 \cdot 16 = 37.7\ \text{l/min.}$$

Thus the maximum oil flow rate to be measured is 37.7 l/min for a pipe ID of 10mm

5.3 Formula to determine the actual oil flow rate for a given pipe ID (in mm)

Example:

Pipe ID	D = 16 mm
Displayed output current	12 mA

$$\frac{d^2 \cdot \pi}{4} \cdot V_x \cdot (A-4) = l/\min.$$

$$\frac{16^2 \cdot 3{,}14}{4} \cdot 0.03 \cdot (12-4) = 48.3\, l/\min.$$

The measurement yields an oil flow rate of 48,3 l/min.

6 What you should know

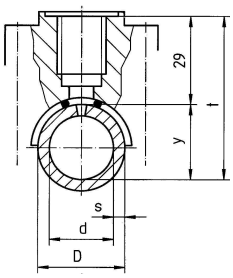
6.1 Determining the correct pipe ID

To determine the precise flow rate

1. y = t – 29
2. s = D – y
3. d = D - 2 x s

Formula to determine the flow rate (Chapter 5)

Example:



Pipe D	= 30 mm
Depth t	= 56,5 mm
Housing	= 29 mm
y = 56.5 – 29	= 27.5 mm
s = 30 – 27,5	= 2,5 mm
d = 30 – (2 x 2,5)	=25 mm

6.2 Diameter of the hole in the pipe: 3.3 mm

The sensor head has a diameter of 3 mm.
The needle which belongs to the flow rate sensor QS-2-B and which is used to punch the hole has a diameter of 3.3 mm.

Make sure that the needle is completely screwed into the housing using measuring connector serv-Clip® SC-2. The needle can penetrate pipe walls with a thickness of 5 mm for sensors with 3mm heads of the flow rate sensor QS-2.

6.3 Measuring cycle

To achieve accurate measuring results, the liquid must flow without major fluctuations for a period of at least 15 seconds.

bkm

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