

CORRSYS
DATRON
Sensorsysteme GmbH



CDS-DFL-3

Fuel Flow Meter

*For Fuel Consumption Measurement
in Mobile Vehicle Instrumentation*

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**USER
MANUAL**

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1 Safety instructions

Please read carefully before operating the sensor.

To assure safe and proper operation of the sensor, the unit must be carefully transported and stored, as well as professionally installed and operated. Furthermore, careful maintenance and usage in accordance with operating instructions is imperative.

This sensor should be installed and operated only by qualified persons who are familiar with devices of this type.

The general approval of the vehicle becomes invalid by mounting the sensor in or at the vehicle.

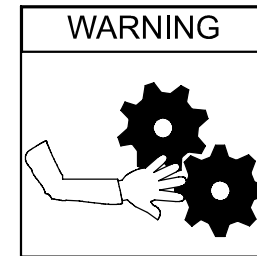
- Use the sensor only for the intended application. Misappropriate application is not allowed.
- Do not modify or change the sensor or its accessories arbitrarily.
- Improper mounting of the sensor affects the security of the vehicle and the passengers.
- When mounting the sensor, please take care that no equipment which is important for the safety of the vehicle will be affected or out of order.
- Assure that the sensor is mounted firmly and securely, in order to prevent the device from slipping or falling.
- Use only the original components, which are included in the scope of supply.
- Do not use a defect or damaged sensor or its accessories.

- Please take care for correct pin assignment and operating voltage when connecting the sensor to the power supply, data acquisition and evaluation systems and other applicable components.

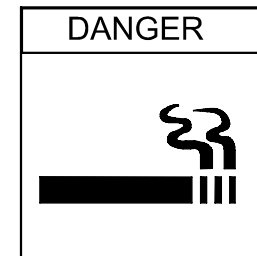
Please note

- Dangers from the engine
- Dangers from the flow meter
- Dangers from the measured medium
- Note the safety and accident prevention procedures
- Regularly check that all precautionary measures are kept to

Should the information provided by these operating instructions not be sufficient, contact the service department of CORRSYS-DATRON Sensorsysteme GmbH for help with further details.



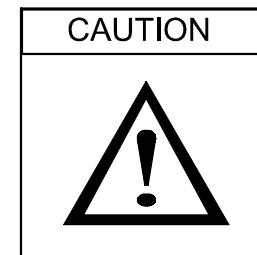
Risk of injury by rotating engine parts



Explosion or fire hazard by leaking fuel



Risk of personal injury



Danger by defects of the pump

2 Description of the measuring unit

The Datron DFL 3 fuel-flowmeter is designed for quick and easy fuel consumption measurement, and is especially suited for use with diesel engines in the range of 37 ... 442 kW (50 ... 600 PS).

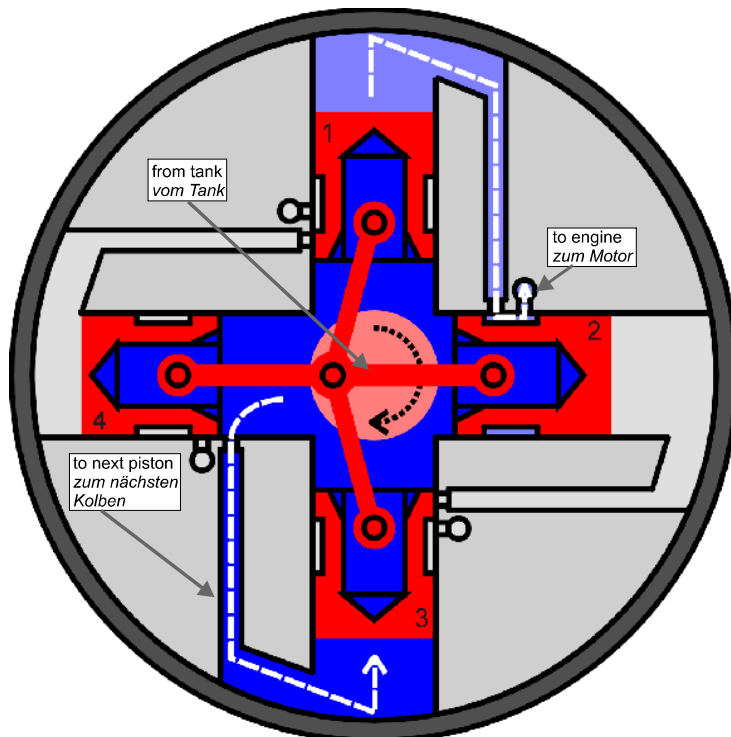
The system is suitable for on-board road tests as well as for test-stand applications. The high measurement accuracy and small dimensions of the DFL 3 enable accurate measurement of DIN (German Industrial Standard) comparative values on a test distance as low as 1 km.

Connected DATRON-EEP, -AEP or - μ EPP devices can calculate consumption quantity to cm^3 and convert it into l/100 km or l/h, as required.

- Quick, easy mounting directly at the vehicle fuel tank
- Automatic ventilation before and during measurement
- Fuel temperature is held constant by the heat exchanger-equipped closed fuel circuit
- Fuel vibration damping
- Pressure compensated transducer
- Suitable for mobile application in test vehicles, as well as with power analyzers or engine dynamometers

2.1 Mode of operation

The mode of measurement is based on a 4-piston counter, in which known piston volume is used to determine consumption. The integrated transducer works on the principle of displacement. First, fuel is forced from the crankshaft space into the cylinders. At the opposite side, the cylinder content is drained into the ring main pipe. As this happens, the rotation of the crankshaft is transformed into electrical pulses via three magnets and two hall sensors.



Each rotation of the crankshaft generates 3 pulses, which are acquired by two hall sensors staggered at 90°. An ascending and descending flank is registered from each pulse, generating a total of 12 flanks per rotation.

1 rotation of the transducer = approx. 4 cm³

1 flank signal = approx. 0.333 cm³

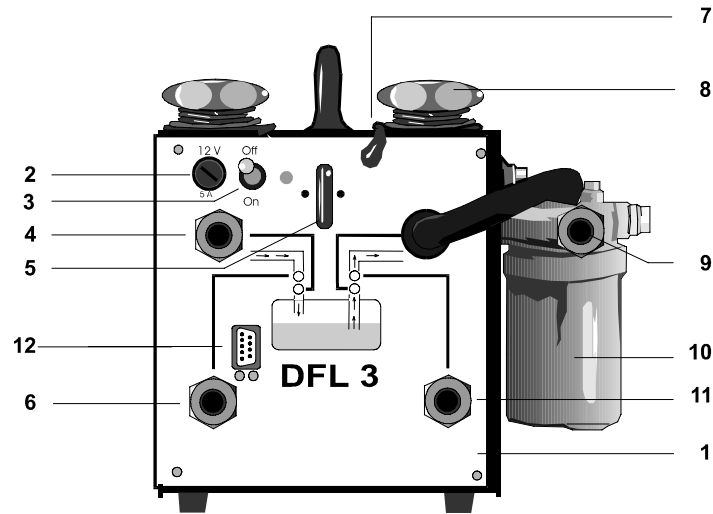
The internal electronics supply an output signal of 500 pulses/cm³ by means of digital pulse multiplication.

In order to consider the fuel return from the engine, consumption is defined as the quantity required to maintain a fixed tank volume. The DFL 3 incorporates an integrated heat exchanger to maximize the accuracy of this measurement. The heat exchanger minimizes temperature differences between feed and return flow, assuring temperature-independent determination of measurement data.

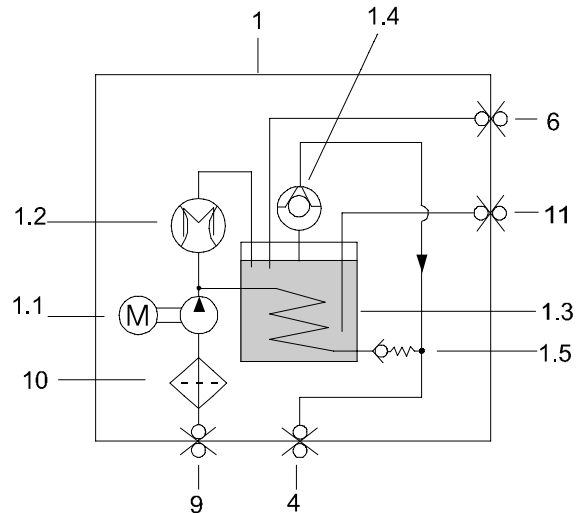
Pressure drop in the piston counter is extremely low and is compensated by a pump in the cooling circuit (pump is not adjustable).

2.2 Component designation

DFL-3 measuring unit with control and connection elements



Symbolic description



The DFL 3 measuring unit is equipped with quick couplings for flexible fuel pipes and should be connected near the fuel tank.

- 1 DFL 3
- 1.1 Electric fuel pump
- 1.2 Transducer
- 1.3 Heat exchanger
- 1.4 Gas bubble / air separator
- 1.5 Pressure relief valve
- 2 Fuse 5 A
- 3 On/Off switch
- 4 Quick coupling for connection with return-flow pipe to fuel tank
- 5 Inspection glass ventilation
- 6 Quick coupling for connection with return-flow pipe from injection pump
- 7 Connecting cable 12 V DC
- 8 Fixing screws for straps
- 9 Quick coupling for connection with fuel pipe from fuel tank
- 10 Fuel filter
- 11 Quick coupling for connection with fuel pipe to feed and injection pump
- 12 Signal output, 9-pin D-Sub-socket

3 Scope of supply



1 DFL-3

4 hoses with barb nipples, 0.7 m

1 universal coupling set

2 retaining straps

1 serial signal cable, 2 m

1 operating manual

Options:

4 cable extensions with quick couplings

1 serial signal cable, 5 m

4 Technical Data

Measuring range	1 ... 150 l/h
Resolution (internal)	0.333 cm ³ / flank pulse
Digital output	500 pulses/cm ³ , TTL-signal
Measuring accuracy	±0.5 % in relation to the actual measuring value
Reproducibility	±0.2 % in relation to the actual measuring value
Media	Diesel
Operating pressure	5 bar max.
Pressure drop	Ambient pressure. Only to be mounted on the suction side of the vehicle's fuel pump!
Max. permitted fuel temperature	170 C° At approx. 70 C° and above, gas bubbles can develop in the fuel. Presence of gas bubbles can result in diminished accuracy!
Vibration damping	approx. 2 %
Shock and vibration resistance	10 g
Temperature range	- 20 C° ... 80 C°

Relative humidity	80 %	
Operating voltage	12 V DC	
Power input	fuel pump	12 V x 2.4 A
	electronics	12 V x 0.8 A
Dimensions	320 x 300 x 290 mm	
Weight	13.2 kg	
Degree of protection	IP 54	
Favorite mounting	vertical	
Measuring volume	recordable quantity per measurement depends upon the data acquisition system used. Example: μEEP - 0 ... 4 200 000 liter at a resolution of 1 cm ³	

The built-in fuel pump is not controllable. External pumps or pressure reduction devices are required for any necessary adjustments to pressure in the fuel pipe to the supply and injection pump.

Calibration value

The calibration value is determined individually for each device. This value is saved in the internal electronics for exact volume calculation. The volume is approx. 4 cm³ per rotation.

The exact volume can be calculated via the calibration value:

$$V_{fi} = \text{calibration value} * 6 / 1000$$

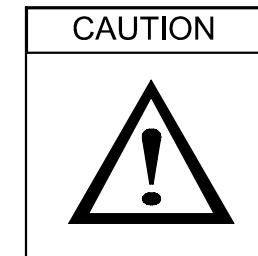
$$V_{fi} = \text{flow rate in cm}^3 \text{ per rotation of the sensor}$$

5 Installation, connection and storage

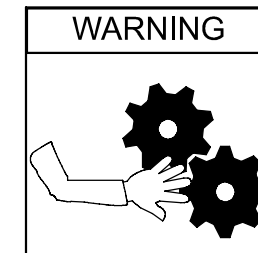
5.1 Pre-installation instructions



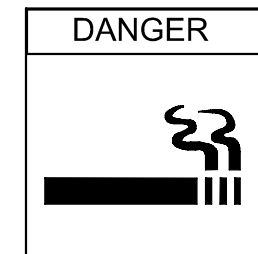
Do not modify or change the DFL 3 measurement device arbitrarily.



Ventilate the device before initial start-up. Do not install the signal cable near the ignition coil.



Risk of injury by rotating engine parts. Stop the engine before installing the DFL 3 unit.



Explosion or fire hazard by leaking fuel.

5.2 Installation and location

Install the DFL 3 directly at the fuel tank.

The DFL 3 should be mounted vertically. Use the provided retaining straps to hold the device in place and to prevent the device from slipping or falling, especially during the test drive.

5.3 Storage

The system is always to be stored in filled condition, i.e., fuel should remain in the system at all times.

Permitted media for fuel consumption measuring:

Permitted:

- diesel

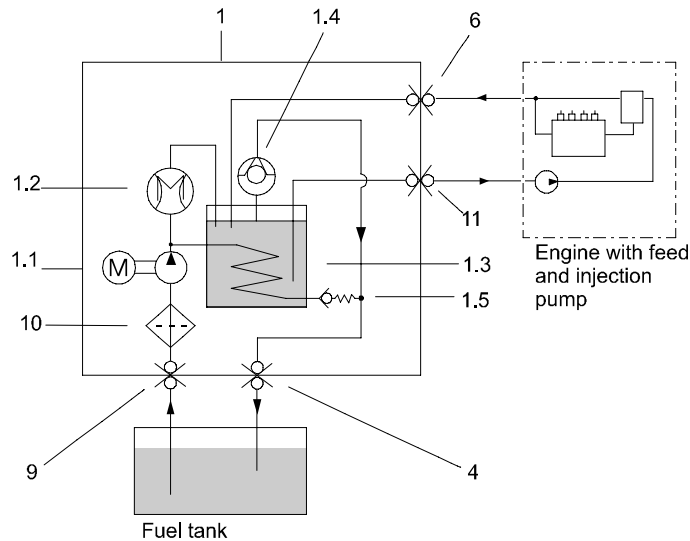
Not permitted:

- regular gasoline
- premium gasoline
- unleaded gas
- leaded, petroleum-based
- Methanol-based fuel
(clarify with producer and indicate composition percentage)

5.4 Mounting

- a) Connect feed and return pipe according to drawing 5.4.1.
- b) Fix the device securely at the fuel tank using the provided retaining straps.
- c) Connect cable 7 to battery (Caution! 12 V).
- d) Switch-on pump with toggle switch 3.
- e) The heat exchanger 1.3 is ventilated after approx. one minute, and the engine can then be started.
- f) The whole system is ventilated after approx. 30 sec. and measurement can then be started.
- g) The function of the automatic ventilator can be checked through inspection glass 5. A continuous trapping of air indicates that the feed pipe from the tank is leaking.

5.4.1 Diagram of fuel circuit during the measurement



- 1 DFL 3
- 1.1 Electric fuel pump
- 1.2 Transducer
- 1.3 Heat exchanger
- 1.4 Gas bubble / air separator
- 1.5 Pressure relief valve
- 4 Quick coupling for connection with the return-flow pipe to the fuel tank
- 6 Quick coupling for connection with the return-flow pipe from the injection pump
- 9 Quick coupling for connection with the fuel pipe from the fuel tank
- 10 Fuel filter
- 11 Quick coupling for connection with the fuel pipe to the feed and injection pump

5.5 Output signals

Internal signal conditioning uses digital pulse multiplication to convert the resolution of $0.333 \text{ cm}^3/\text{flank}$ impulses to an output signal of 500 pulses/cm^3 . The signal conditioning component also controls fuel flow direction, which is displayed via the green LED.

Reaction to dynamic consumption

A complete rotation of the transducer is required to ensure accurate consumption measurement. One rotation corresponds to approx. 4 cm^3 . The total number of pulses at the output of the signal conditioning unit always corresponds to the number of pulses at the input of the signal conditioning unit ("raw" pulses). This is managed by a time-based comparison of the input and output pulses. To get accurate data, a floating mean value per one revolution is produced (3 pulses resp. 12 flanks). This causes a delayed output of the actual consumption. With linear alteration and a consumption of 14.4 l/h the time range is exactly 1 s.

$$14.4 \text{ l/h} = 4 \text{ cm}^3/\text{s}$$

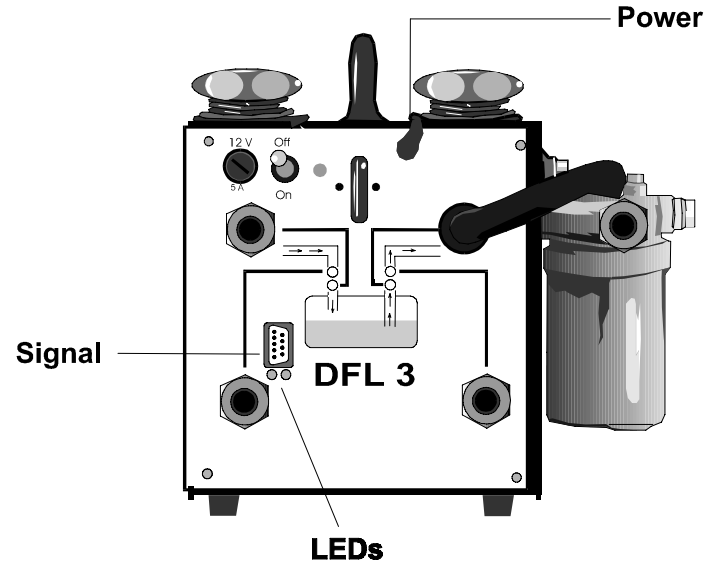
$$4 \text{ cm}^3 = 1 \text{ rotation of the sensor}$$

$$1 \text{ rotation of the sensor} = 1 \text{ s}$$

Respectively, the time range is higher at lower consumption rates. As a result, it is not possible to register fast changes in consumption!

This means: *Only the inspection of the total consumption provides accurate values.*

Actual consumption is subject to the above-mentioned shortcomings.



Power supply: A supply cable connects the DFL 3 to the vehicle electrical system (12 V).

LEDs: Green
The green LED blinks with clock pulses of 1 sec. (about 1 sec. on, 1 sec. off), which indicates the DFL 3 ready state.

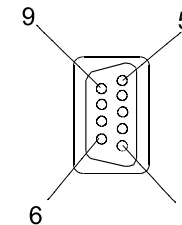
A faster blinking of the green LED indicates incorrect flow direction. In this case, carefully re-connect hoses per specification to correct the flow direction.

Red
The red LED blinks when reading a flank from the transducer. Running direction of the transducer is not indicated by this LED.

Signal: 9-pin D-Sub-socket

- Pin 1 reserved
- Pin 2 TTL out / TxD out
TTL signal = 500 pules/cm³
- Pin 3 RxD
- Pin 4 Interface identification
-12 V = interface active
open = TTL-output active
+12 V = TTL-output active
- Pin 5 Digital GND
- Pin 6 reserved
- Pin 7 reserved
- Pin 8 Original pulses from hall sensor A
3 pulses / rotation of sensor
3 pulses = 4 cm³
- Pin 9 Shield (housing)

Socket in the device



6 Correcting errors

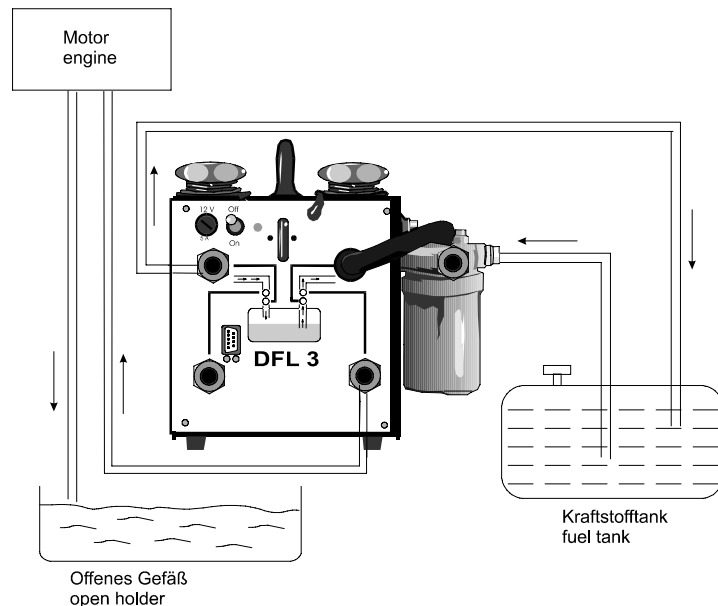
6.1 Engine power below standard

- The engine does not reach full power or misfires during high performance.

Cause: The pump in the cooling circuit does not supply sufficient fuel.

Remedy: Replace fuel filter 10 (must be replaced after distances of 5 - 10000 km).

6.2 Engine does not start



To check the entire measuring system we recommend the following approach:

- Separate the return flow pipe from the engine at coupling no. 6 and put the pipe into an open tank (see diagram).
- Switch on the pump with switch no. 3.
- The counter should display the quantity of fuel pumped into the open tank (approx. 80 - 100 l/h).

Possible errors:

- Absolutely no fuel flows into the open tank

Cause: The transducer is blocked.

Remedy: Slight compression of return hose to the tank at coupling no. 4.
If this fails, send the system back: transducer 1.2 will have to be replaced.

- No reaction is audible when switching on the cooling circuit pump with switch 3.

Cause: The engine is not running.

Remedy: a) Change fuse 2 (5A)
b) The engine 1.1 has to be replaced
(a blocked pump caused burned coils).

6.3 Checking the transducer

Testinstallation as described in chapter 6.2

Possible errors:

- Absolutely no fuel flows into the open tank

Cause: The transducer is blocked.

Remedy: Slight compression of return hose to the tank at coupling no. 4.
If this fails, send the system back: transducer 1.2 will have to be replaced.

- The open tank is being filled but the quantity is not displayed.

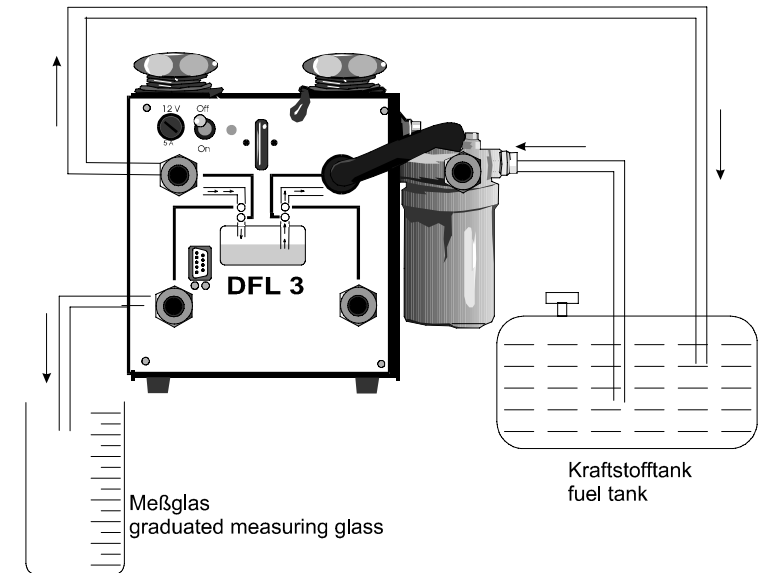
Cause: The internal cable between transducer and electronics is interrupted.

Remedy: Replace transducer cable and transducer.

Cause: Serial signal cable is interrupted.

Remedy: Repair or replace signal cable.

6.4 Checking accuracy

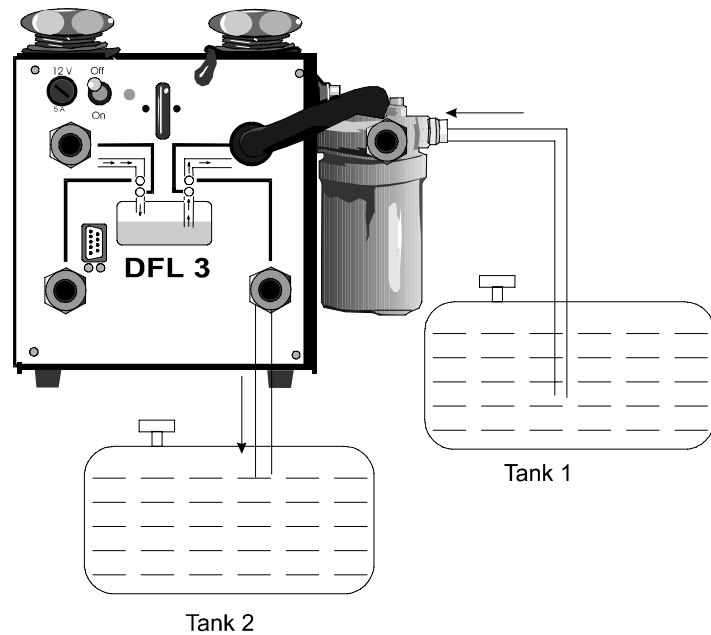


Place hose after coupling 6 into a measuring glass. Compress the end of the hose in order to block fuel flow. When the system is ventilated, the display should come to a standstill. If not, the air separator 1.4 should be checked through the inspection glass 5. Gas bubbles still arising after operating the pump for 1 - 2 minutes indicates a leak in the flow pipe from the tank.

Remedy: Check the connections of the suction pipe for leaks at coupling 9.

Set the display to zero and fill 1 l of fuel into the measuring glass. If the deviation is higher than 1 %, operate the transducer for 5 - 10 minutes and check again.

6.5 Filling the heat exchanger with fuel



This operation may be necessary if the DFL 3 sensor is not used for prolonged periods of time (approx. 1 month).

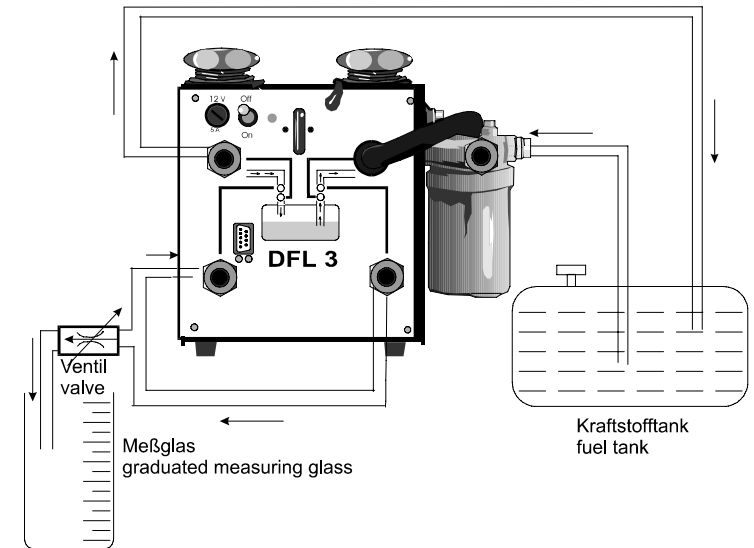
Fill the unit with fuel to completely ventilate the heat exchanger.

Connect the pipes according to the diagram. The use of two separate tanks is recommended in order to avoid mixing new fuel with previously used fuel (perhaps of different qualities).

Switch the DFL 3 on and operate the pump for approx. 10 minutes.

The through-flow velocity should be 150l/h to 180 l/h.

6.6 Checking constant flow rate



Follow these procedures to test the constant fuel flow rate. It is imperative that the data acquisition system displays a constant flow value. Leaps in the range of ± 1.5 l/h are not acceptable. First, connect the pipes according to the diagram. Next, install a valve between hose after coupling 11 and hose after coupling 6. Lead the hose into a measuring glass after passing the valve. Adjust the valve to a flow of approx. 1 l/h (approx. $0.277 \text{ cm}^3/\text{s}$). Switch on DFL 3 and check values.

Possible errors:

- The fuel consumption indicator shows large leaps during constant fuel flow.

Cause: Air in the heat exchanger, the unit is not completely filled with fuel.

Remedy: Fill heat exchanger with fuel (see 6.5).

- Cause:** Periodic faults due to a blocked pair of pistons. This effect may appear when the system has not been used for quite some time. This is caused by sediments or a light sticking of the measuring pistons within the cylinder.
- Remedy:** Warm-up the system according to connection diagram chapter 6.5 (in this case feed and return flow pipe can be incorporated in one tank). Warm-up time may be up to 2 hours.

7 Application examples

The following tests are based on the system installation of chapter 6.6, "Checking the constant flow rate".

Acquisition and evaluation of the average consumption

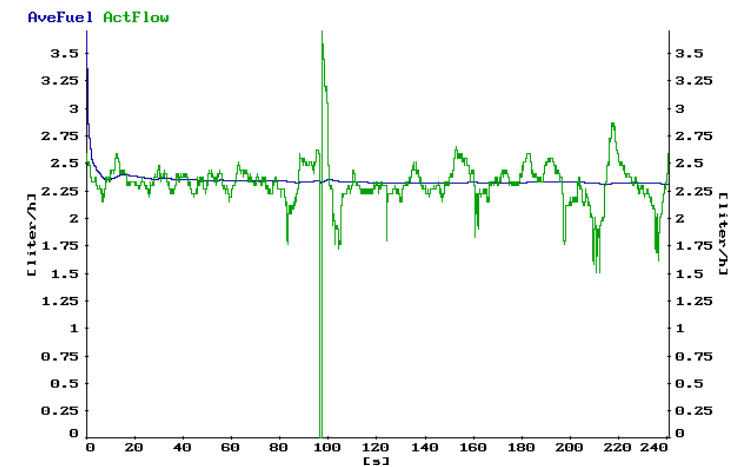
Signals: **AveFuel** (average consumption)
 Formula: summed pulses / summed time
 Unit: l/h

ActFlow (actual consumption)
 Formula: pulses / time basis of 200 ms
 Unit: l/h

Test period: 240 s

Fuel consumption: approx. 2.3 l/h

Scanning rate of signals: 100 ms

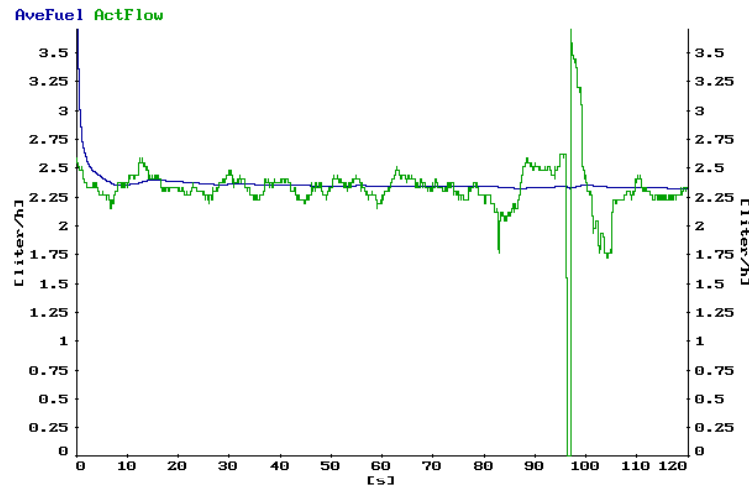


Fuel consumption per time, axes adjusted

These extraordinary leaps in the graph of the **ActFlow** signal are not representative. These processes typically occur after a prolonged period of disuse or when suspended particles are present in the fuel medium, producing a negative influence on the precision measuring device.

Remedy: Increase warm-up time (see also chapter 6 "Removing errors").

Furthermore, observation of the constantly developing graph of the **AveFuel** signal or a more uniform segment of the **ActFlow** graph (e.g. period 0 - 80 sec.) is recommended. For a representative view of the **ActFlow** signal, please consider the average values determined for the complete measurement.



Irregularity between 95 and 100 s, extended scale

A test with periodic appearance of these processes is described at the end of the chapter (see: error handling).

Characteristic of the different pulse signals

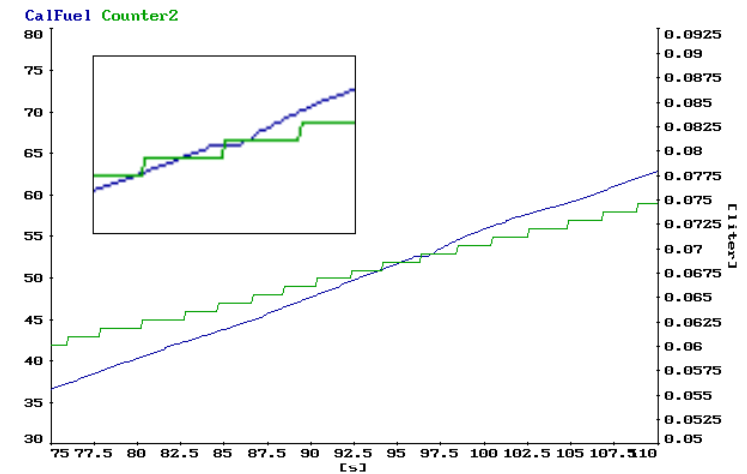
Signals: **CalFuel** (500 pulses/cm³, 1 pulse = 0,002 cm³)
 Formula: summation of the pulses * 2 * 10⁻⁶
 Unit: l

Counter2 ("raw" pulses of hall sensor A,
 3 pulses = approx. 4 cm³)
 Formula: Summation of the pulses
 Unit: Pulses

Test period: 35 s

Fuel consumption: approx. 2.3 l/h = 0,02236 l in 35 s

Scanning rate of signals: 100 ms



Pulse signals, Y-axes not adjusted

The detail shows the characteristic line of signal **CalFuel** during the zero decrease of the consumption.

Acquisition and evaluation of actual average consumption

Signals: **ActFlow** (actual consumption)

AvgActFlow (actual average consumption)

Formula: Floating calculation of mean value per

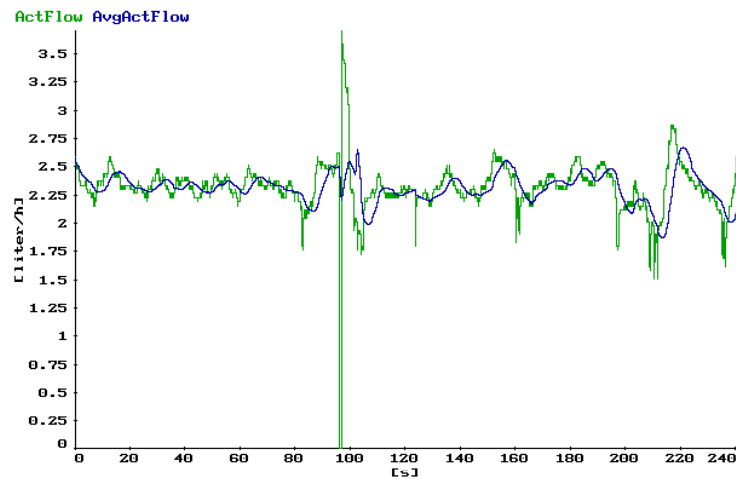
ActFlow

Unit: l/h

Test period: 240 s

Fuel consumption: approx. 2.3 l/h

Scanning rate of signals: 100 ms



Phase shift of signal AvgActFlow

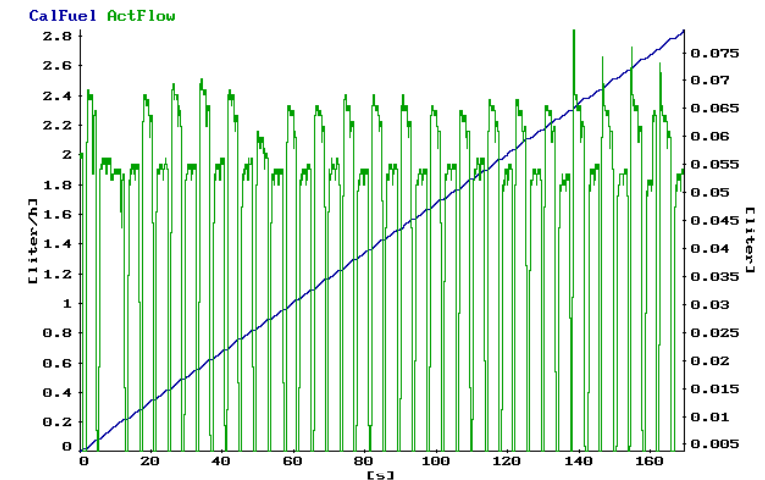
The dynamic **ActFlow** signal exhibits more noise than the **AveFuel** signal. Due to its mathematical definition, the **AveFlow** signal stabilizes over time.

Average actual consumption is computed in order to improve the noiseless representation of actual consumption. The **AvgActFlow** signal is produced by covering the **ActFlow**

signal with a floating mean value, which is the product of averaging the phase-shifted computed signal.

Error handling

Warm-up the system before starting the test. The accuracy of the sensor depends on the warm-up period, as the four-piston counter may indicate incorrect values due to the presence of sediments. A long lead-time ensures a sufficient purge of the measuring chamber. Should the following irregularity occur periodically, it may be the result of an insufficient purge time (see chapter 6.6 "Checking the constant flow rate").

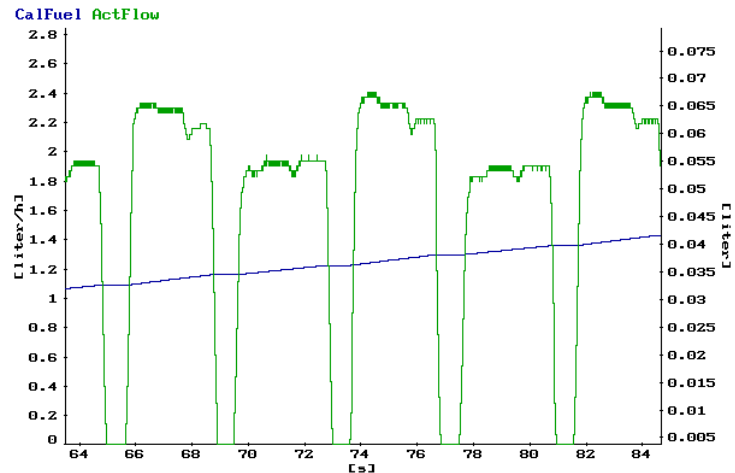


Interfering signals after cold start

Such periodic faults result when a pair of pistons becomes sticky.

This effect may occur when the system was not used for quite a time. This is caused by sediments or a light sticking of the measuring pistons within the cylinder.

More severe faults or even damage may occur if the system is not stored in filled condition.



Periodic fall of measurement values, extended scale

8 Warranty and service

A careful and accurate treatment of the DFL 3 sensor is presumed. This includes:

- use only for the described applications, no abuse of sensor
- check functions before each use
- regular care and cleaning
- safe transport and adequate storage

Warranty

Warranty is granted for one year on material and functions.

We warrant a faultless product.

All information given about application and accuracy are not binding and are based on application experiences. These do not free the user to make checks himself.

There will be no warranty for damages or resulting costs, caused by inappropriate application of the product.

Service

All devices, as well as the software were manufactured and tested with greatest care and according to the latest technical standards.

If you, however, find reason to complain using the devices, we kindly ask not to try to solve the problem on your own. In this case, please contact our company representation in your country, or directly contact our central service team under following adress:

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