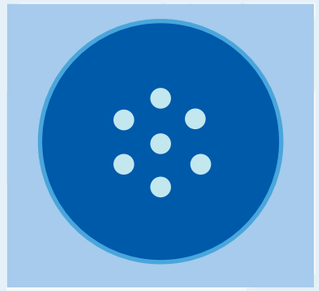
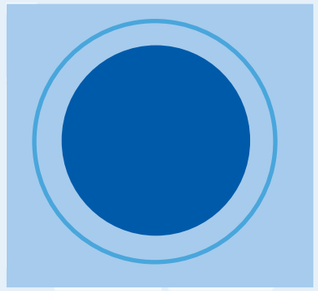
Laminar Flow Elements – types and measurement ranges

Capillary LFE



Measurement ranges from 5 up to 1,300 ml/min

Gap LFE



Measurement ranges from 0.01 up to 150 l/min

Matrix LFE

Measurement ranges from 2.8 up to 64,000 l/min

Standard LFEs are suitable for the flow measurement of all gases. The ranges given above are based on air under atmospheric conditions of 20 °C, 1000 mbar, 0% relative humidity. The LFEs are made in various sizes from 1/4" to 16" for nominal flow rates with a differential pressure of 1, 5, 10 and 20 mbar. It should be noted that the differential pressure is also simultaneously a constant pressure drop.

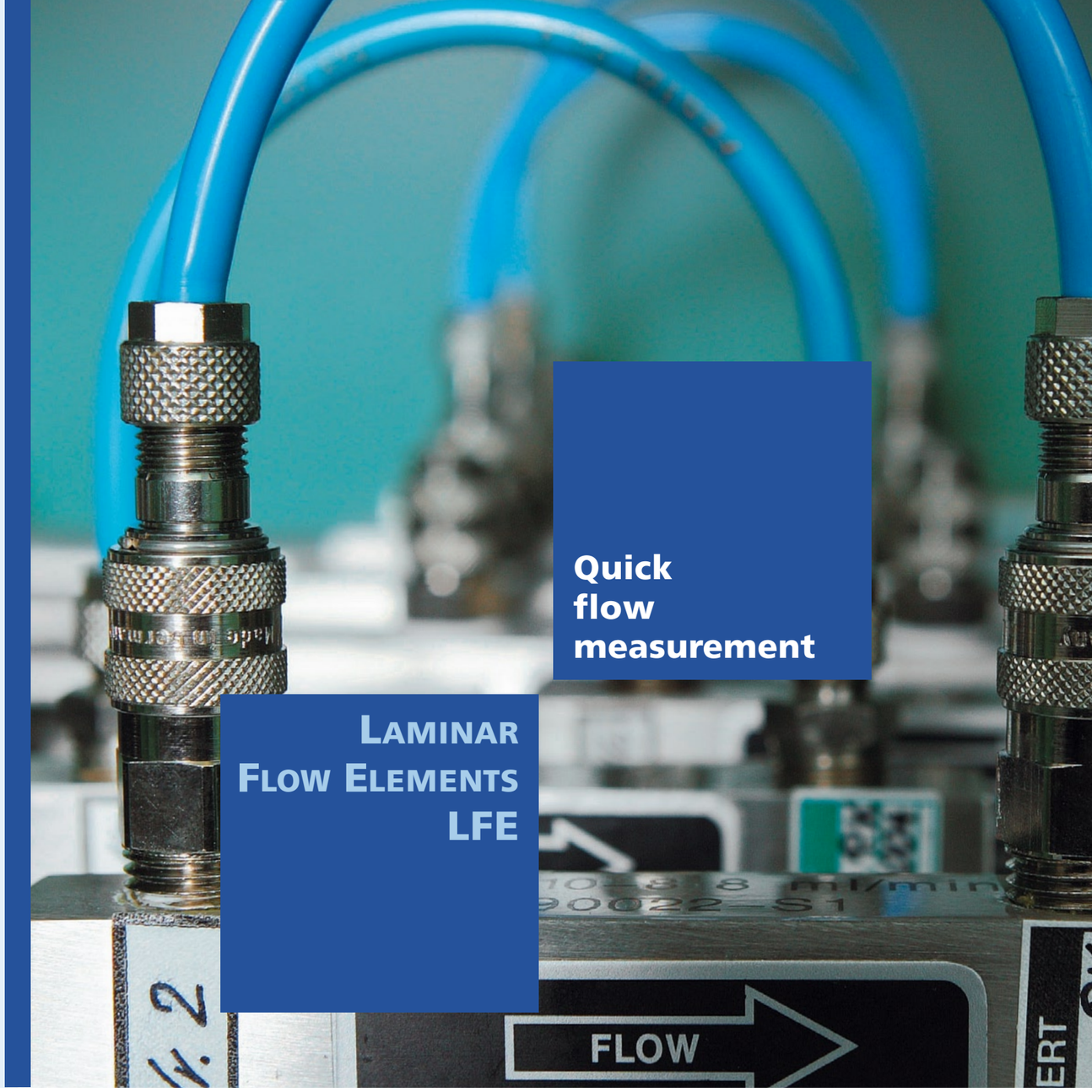
Ranges of use and limitations

Absolute pressure	of 100 mbar up to 10 bar absolute
Temperature	from 0 to 70 °C
Relative humidity	from 0 to 100%, non-condensing

Fluctuating pressures, temperatures and humidity influences should be corrected with high accuracy requirements in the viscosity and density calculation of the medium. The viscosity of most gases remains at about 6 bar independent of pressure. However a shift in the calibration curve of about 1% per bar effect (pressure difference relative to calibration conditions) occurs because of compression effects on the capillary inlet pressure dependencies in the evaluation according to Hagen-Poiseuille. This can be avoided either by calibration at medium operating pressure or can be corrected by the „universal flow" evaluation.

Requirements of the measurement set-up

To avoid strong fluctuations and variations in the differential pressure caused by turbulence in the LFE, a straight inlet pipe of approximately 10-fold and a straight outlet pipe of about 5-fold of the LFE inner diameter should be maintained. The installation position is optional, however, the direction of flow indicated by the arrow should always be adhered to. If this arrangement is not possible, then a LFE calibration should be carried out together with the actual pipe tube set-up of the flow element.



Quick flow measurement

Laminar Flow Elements LFE

TetraTec Instruments®

Gewerbestr. 8, 71144 Steinenbronn, Germany
Phone: +49/(0)7157/5387-0, Fax: +49/(0)7157/5387-10
eMail: info@tetratec.de · **www.tetratec.de**

Precise Flow · Calibration · Test Equipment

TetraTec Instruments®

Laminar Flow Elements LFE

Together with the automated evaluation methods that we offer, LFEs can play to their strengths in many applications or enable new applications in industry and research:

- Low drop in pressure
- Very good linearity
- Large measuring ranges from a few ml/h to as much as m³/h
- Most repeatability
- High long-term stability
- Absolute accuracy
- Lightning-quick response

LFEs offer the outstanding advantages of an effective and safe monitoring of product quality:

- Measurement of the air intake of internal combustion engines
- Performance measurement in fans
- Leakage testing and the determination of characteristics of valves
- Flow measurements and testing in the automotive industry

Quick and precise flow measurement

Laminar Flow Elements, LFEs for short, are classic differential pressure elements for volume flow measurement. LFEs basically consist of a large number of parallel capillaries, so that the Hagen–Poiseuille equation is applicable as a good approximation. It defines the linear correlation of differential pressure and volume flow in capillaries.

Due to the linear relation LFEs are superior to other differential pressure transducers (e.g. orifices, nozzles, pitot tubes...), that are built upon the quadratic correlation between mass flow and differential pressure. The linear relation allows a wider measuring span, and in particular measurements in conjunction with a small Reynold's number.

Compact structure – modular design

In order to meet with changing requirements, our LFE structures offer the following advantages:

- Variable, modular measurement set-up
- Wide range of sizes and measuring ranges
- Various types of LFE
- High-precision sensors for differential and absolute pressure, temperature and humidity
- Evaluation units
- Methods for calculation and correction

With flow measurements a compromise always has to be found between the costs and any uncertainty in measurement. Our LFE measurement set-ups take into account:

- Short response time
- Small dead volumes
- Modular concepts regarding mechanics, sensors and evaluation electronics

This ensures a quick set-up and replacement for maintenance and recalibration. In order to ensure the same evaluation process under changing operating conditions as existed during the calibration process, absolute pressure, temperature and optionally humidity should all be measured before the LFE.

Measuring air and gases with wide ranges

Measuring principle: The differential pressure is proportional to the flow

At the heart of a LFE is the capillary matrix. The gas flows evenly dispersed through a large number of parallel-connected single capillaries. The matrix is designed in such a way that a laminar velocity of flow profile occurs at the nominal flow range setting. This gives rise to a drop in pressure as the gas flows through the matrix because of the viscous friction of the gas layers against one another and the interaction with the tube wall. The difference between the static absloute pressures at the input and output is directly proportional to the flow.

Very good linearity

The linearity of the differential pressure flow characteristic is an essential feature. It makes it possible for the LFEs to be used over a wider flow range than other conventional differential pressure elements. In many applications a single LFE is able to cover a measuring range which would normally require several so-called square root devices such as Venturi nozzles or measuring orifices.

Very large measuring span

Due to the linearity of the LFE characteristic in the Laminar Flow Element differential pressure and flow rate are directly proportional to each other. A change in flow rate of 1:10 also causes a change in the differential pressure of 1:10. If large measuring ranges from 1:100 have to be measured, the repeatability with LFE can be kept readily at the same level with each 1:10 through the use of two cascaded differential pressure sensors.

Fast response

According to the thermodynamic flow set-up and the dynamic behaviour of the sensors, pressure appears as the first stable (stationary) quantity. For example, with piezo-resistive and capacitive measuring cells a step response of 100% within a few milliseconds can be detected. However calorimetric measurement methods can require times of between 1 to 100 seconds by comparison.

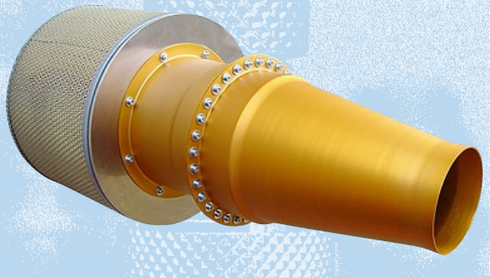
Very good repeatability and long-term stability

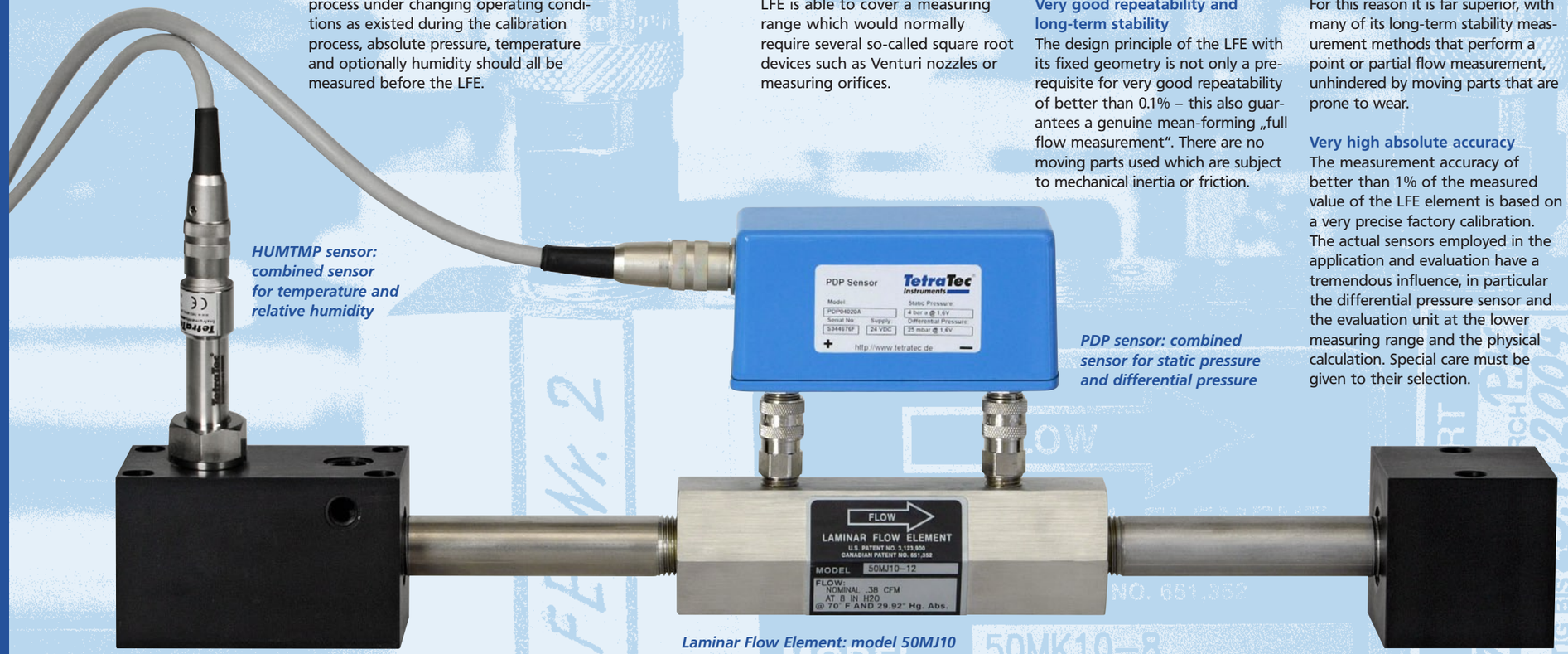
The design principle of the LFE with its fixed geometry is not only a prerequisite for very good repeatability of better than 0.1% – this also guarantees a genuine mean-forming „full flow measurement". There are no moving parts used which are subject to mechanical inertia or friction.

For this reason it is far superior, with many of its long-term stability measurement methods that perform a point or partial flow measurement, unhindered by moving parts that are prone to wear.

Very high absolute accuracy

The measurement accuracy of better than 1% of the measured value of the LFE element is based on a very precise factory calibration. The actual sensors employed in the application and evaluation have a tremendous influence, in particular the differential pressure sensor and the evaluation unit at the lower measuring range and the physical calculation. Special care must be given to their selection.





HUMTMP sensor: combined sensor for temperature and relative humidity

PDP sensor: combined sensor for static pressure and differential pressure

Laminar Flow Element: model 50MJ10