

# Quality Assurance for Gas Density Sensors

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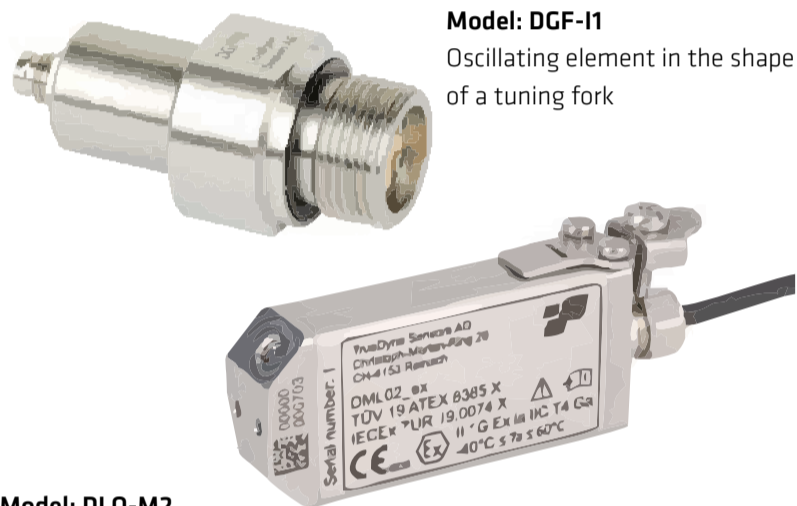
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## Gas Density Sensors

There are a lot of commercially gas sensors available. In most use cases, these sensors are used to determine a specific gaseous compound. The test lab in Division 8.1 received a request to test sensors for gas density to support the determination of process gas composition. Devices under test (DUT): Truedyne DGF-I1 and Truedyne DLO-M2.

- Direct installation into a pipeline
- Gas density measurement at ambient pressure
- Principle: Variation of the oscillator frequency of a MEM component as a function of the gas density



Model: DLO-M2

Tiny silicon tube is set in vibration

## Gas Density Fundamentals

General density definition:  $\rho = \frac{m}{V}$

Virial coefficient equation: (linear approximation)  $B'(T) = B'_0 + (B'_{30} - B'_0) \cdot \frac{\vartheta}{30^\circ\text{C}}$

Compressibility factor:  $Z(p, T) = 1 + B'(T) \cdot p$

General density definition:  $\rho(T, p) = \frac{pur \cdot p \cdot M}{Z(p, T) \cdot R \cdot T}$

$\rho$  = gas density [kg/m<sup>3</sup>]

$m$  = mass [kg]

$V$  = volume [m<sup>3</sup>]

$p$  = gas pressure [Pa]

$pur$  = gas purity

$M$  = molar mass [kg/mol]

$Z$  = compressibility factor

$R$  = universal gas constant with

8.314462618 J/(kg/mol)

$T$  = temperature [K]

$B'_0$  = first linear virial coefficient

[1/Pa]

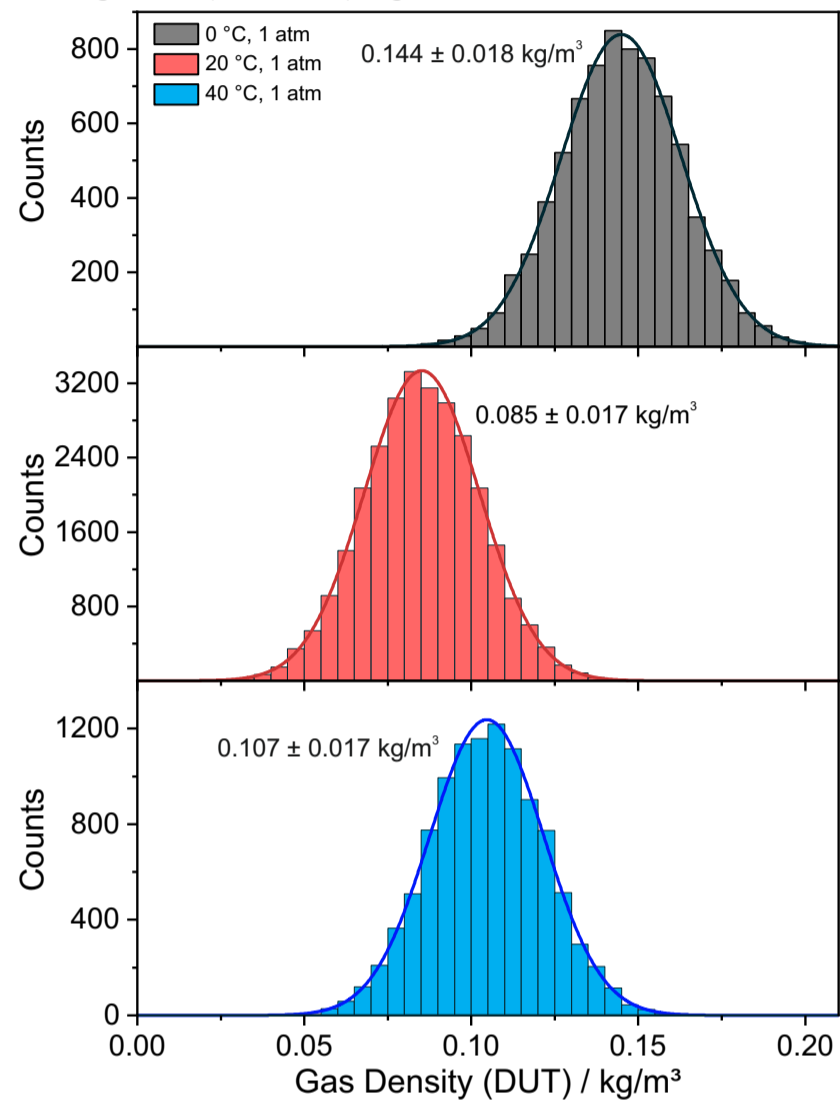
$B'_{30}$  = second linear virial coefficient

[1/Pa]

Element	Symbol	Molar Mass / kg/mol	B' <sub>0</sub>	B' <sub>30</sub>
Carbondioxide	CO <sub>2</sub>	0.0440090	-6.690	-4.750
Hydrogen	H <sub>2</sub>	0.0020160	0.605	0.574
Nitrogen	N <sub>2</sub>	0.0280100	-0.452	-0.151

## Gas Density Results

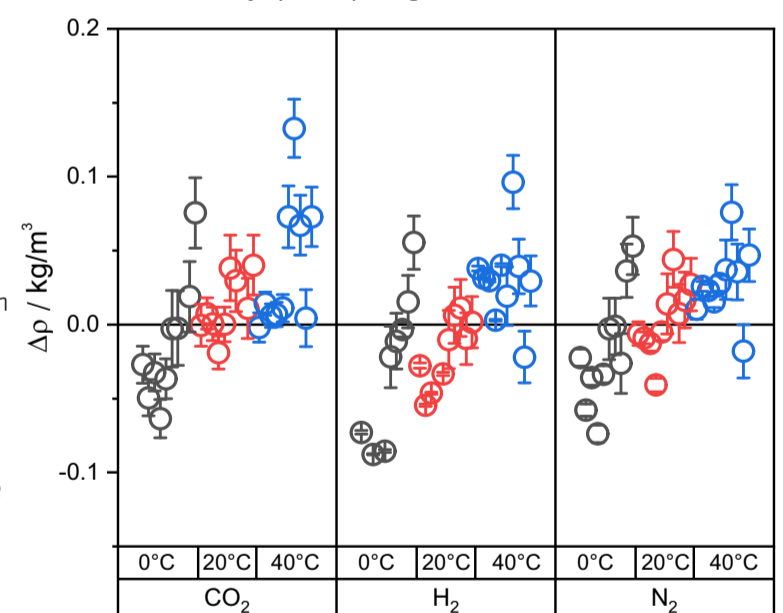
Histograms of one gas density sensor in hydrogen:



### Measurement Results of DLO-M2 & DGF-I1

Reference values were calculated according to equation of state (EoS) of DIN EN ISO 14912:2006-11 with respect to gas temperature and pressure

Measuring error expressed as difference of DUT mean value with respect to the reference value



### Conclusion

- The tests demonstrated the principal applicability in hydrogen, nitrogen, and carbon dioxide of gas density sensors
- With the knowledge of gas density and the measurement uncertainty, it is possible to use these devices for process control of gases or gas mixtures like hydrogen or hydrogen-enriched natural gas.
- Test performed at three gas temperatures at 0 °C, 20 °C and 40 °C and ambient pressure
- Applied equation of state for gas density with respect to DIN EN ISO 14912:2006-11