

TC (VOL%) SENSOR APPLICATIONS AND CORRECTION FACTORS

LEL/VOL% SENSOR

RAE Systems' unique combination LEL/TC (lower explosive limit/thermal conductivity) sensor allows the measurement of many gases in both the sub-explosive and the volume % ranges. Currently, only methane can be used to switch automatically between LEL and Vol% measurements. However, volume % measurements in the range of 2 to 100% can be made for many other gases.

Operating Principle

The TC sensor operates on the principle of the cooling effect caused by the gas as it passes over a heated wire coil. As the coil cools, the resistance decreases in proportion to the thermal conductivity of the gas. In RAE Systems TC/Vol sensors, the TC coil is part of a Wheatstone bridge that is integral to the LEL sensor (see figure below). In the LEL mode, the coil acts as the reference bead and the catalytically active bead is connected to the bridge. In the TC/Vol mode, the active bead is disconnected and only the deactivated reference bead is used.

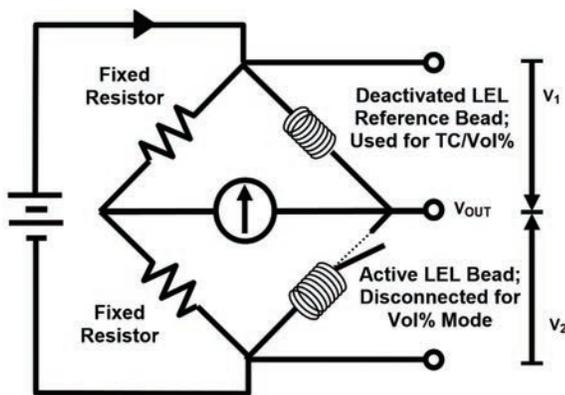


Figure 1.

Each type of gas has a unique TC and thus a unique relative response. For this sensor, the gas does not need to be combustible, and no oxygen is required for its operation. Almost any gas can be measured as long as it has a different TC than the matrix gas. For example, CO₂ can be measured in air, or H₂ in argon. The TC may be either higher or lower than that of the matrix gas.

Calibration Methods

Two methods can be used to calibrate the TC sensor:

1. Directly with the gas of interest.
2. Using a reference gas and a correction factor or look-up table.

Table 1 is a list of Correction Factors (CFs). These values are to be multiplied by the observed readings (calibrated to methane or butane) to obtain the true volume % values. No Correction Factors are built into instruments using the TC sensor, and the multiplication needs to be done manually. No CFs should be used when calibrating with the gas of interest.

It is important to zero the TC sensor with the matrix gas. For example, nitrogen or synthetic air give a different zero response than ambient air, which contains both about 1% argon and 1 to 2% water vapor. These minor components cause a few vol % offset in the zero reading, which affects the lower detection limit.

Table 1. TC Sensor Sensitivity to Various Gases & Vapors*

Gas	CF in Air vs. CH ₄	CF in N ₂ vs. CH ₄	CF in N ₂ /CO ₂ vs. butane
Hydrogen	0.38	0.25	
Helium	0.19	0.19	0.07
Argon	-2.7	-3.0	-1.2
Carbon Dioxide	-6	-17	
Vinyl Chloride		9	
Methane	1.00	1.00	0.38
Methanol	5.3	4.5	1.7
Ethane	1.9	1.5	0.6
Ethylene	1.7	2.3	0.6
Ethanol	5.1	4.4	1.6
Propane	2.5	2.1	0.8
Propene	4.9	2.4	0.9
n-Butane	3.2	2.7	1.00
Isobutane	3.2	2.9	1.1
Isobutylene	3.4	3.6	1.2
n-Pentane	5.5	4.3	1.7
n-Hexane	13	9	3.1

* Values in italics are calculated from the thermal conductivity at 600 K, which generally agree with the measured values within 10%.

The plot in Figure 2 is a sample response curve for carbon dioxide in air matrix calibrated with either CO₂ or methane.

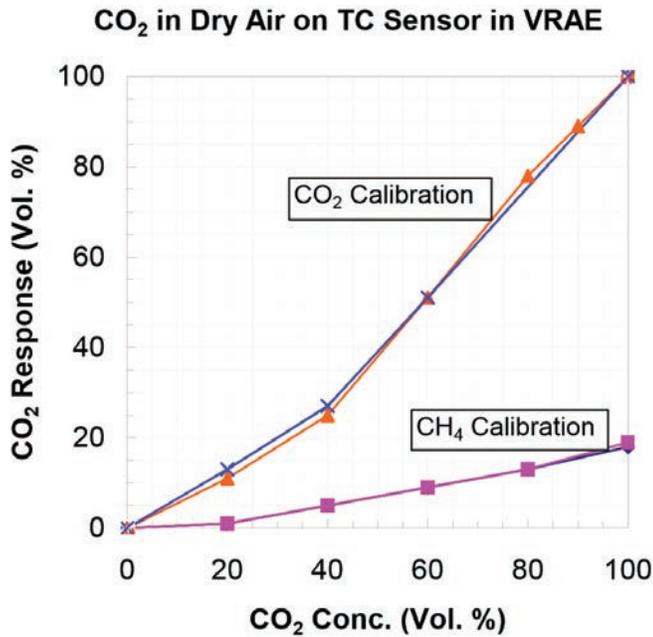


Figure 2. Sample response curve for CO₂.

Negative Response Inversion

Some compounds have lower TC than air or nitrogen and therefore give a negative response on the TC sensor. Any negative responses are converted to positive readings by the VRAE firmware. Mixtures of gases behave in an additive manner. Therefore, gases like CO₂ and argon, which have negative responses, reduces the response of gases with positive responses, like most hydrocarbons.

Other Special Considerations

Combustible vapors (except methane) can be measured only in the absence of oxygen, because a small amount of oxidation can occur on the hot coil. Every vol % of oxygen reduces the response by 2 vol % propane equivalent or less. Inert compounds such as argon, helium, and CO₂ can be measured in the presence of oxygen.

Vinyl Chloride and similar polymerizable compounds may form a coating on the sensor if measured at 100 vol %, and should be measured at <80 vol %.