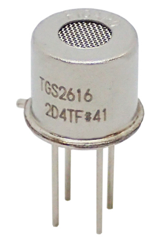
FIGARO
an ISO9001 company

Technical Information for Hydrogen Gas Sensors

The Figaro 2600 series is a thick film metal oxide semiconductor, screen printed gas sensor which offers mini-aturization and lower power consumption. The TGS2616-C00 displays high selectivity and sensitivity to Hydrogen gas.



See also Technical Brochure 'Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors'.

IMPORTANT NOTE: OPERATING CONDITIONS IN WHICH FIGARO SENSORS ARE USED WILL VARY WITH EACH CUSTOMER'S SPECIFIC APPLICATIONS. FIGARO STRONGLY RECOMMENDS CONSULTING OUR TECHNICAL STAFF BEFORE DEPLOYING FIGARO SENSORS IN YOUR APPLICATION AND, IN PARTICULAR, WHEN CUSTOMER'S TARGET GASES ARE NOT LISTED HEREIN. FIGARO CANNOT ASSUME ANY RESPONSIBILITY FOR ANY USE OF ITS SENSORS IN A PRODUCT OR APPLICATION FOR WHICH A SENSOR HAS NOT BEEN SPECIFICALLY TESTED BY FIGARO.

1. Basic Information and Specifications

1-1 *Features*

* High selectivity to Hydrogen
* Small size and low power consumption
* Uses simple electrical circuit

1-2 *Applications*

* Hydrogen detection for steel plant safety
* Portable gas detectors
* Leak detection for gas appliances
* Hydrogen leak detectors for fuel cells

1-3 *Structure*

Figure 1 shows the structure of TGS2616-C00. Using thick film techniques, the sensing material (SnO_2) is printed on electrodes (noble metal) which have been printed onto an alumina substrate. One electrode is connected to pin No.2 and the other is connected to pin No.3. The sensor element is heated by RuO_2 material printed onto the reverse side of the substrate and connected to pins No.1 and No.4.

Lead wires are Pt-W alloy and are connected to sensor pins which are made of Ni-plated Ni-Fe 50%.

The sensor base is made of Ni-plated steel. The cap is stainless steel. The upper opening in the cap is covered with a double layer of 100 mesh stainless steel gauze (SUS316).

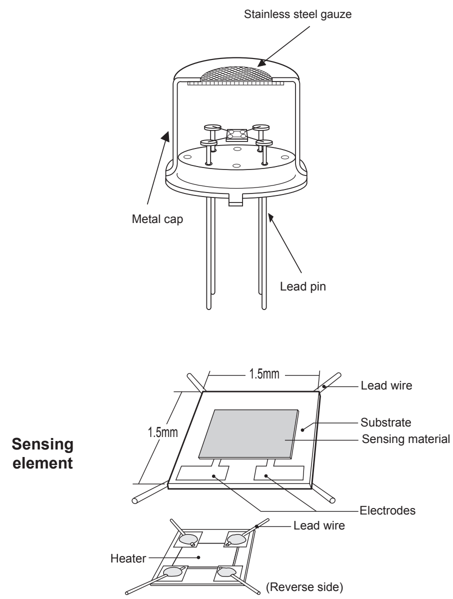


Fig. 1 - Sensor structure

1-4 *Basic measuring circuit*

Figure 2 shows the basic measuring circuit. Circuit voltage (Vc) is applied across the sensor element which has a resistance (Rs) between the sensor's two electrodes and the load resistor (R_L) connected in series. When DC is used for Vc, the polarity shown in Figure 2 **must** be maintained. The Vc may be applied intermittently. The sensor signal V_{OUT} (V_{RL}) is measured indirectly as a change in voltage across the R_L. The Rs is obtained from the formula shown at the right.

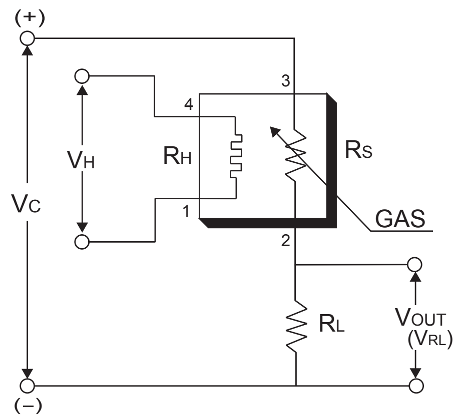


Fig. 2 - Basic measuring circuit

NOTE: In the case of V_H, there is no polarity, so pins 1 and 4 can be considered interchangable. However, in the case of V_C, when used with DC power, pins 2 and 3 must be used as shown in the Figure above.

$$Rs = \left(\frac{Vc}{V_{RL}} - 1 \right) \times R_L$$

Formula to determine Rs

1-5 *Circuit & operating conditions*

The ratings shown below should be maintained at all times to insure stable sensor performance:

Item	Specification
Circuit voltage (V_C)	5.0V ± 0.2V DC
Heater voltage (V_H)	5.0V ± 0.2V DC
Inrush heater current (V_H=5.0V)	100mA max.
Heater resistance (room temp)	approx 59Ω
Load resistance (R_L)	variable (0.45kΩ min.)
Sensor power dissipation (P_S)	≤15mW
Operating & storage temperature	-10°C ~ +50°C
Typical detection range	30~3000ppm

1-6 *Specifications* NOTE 1

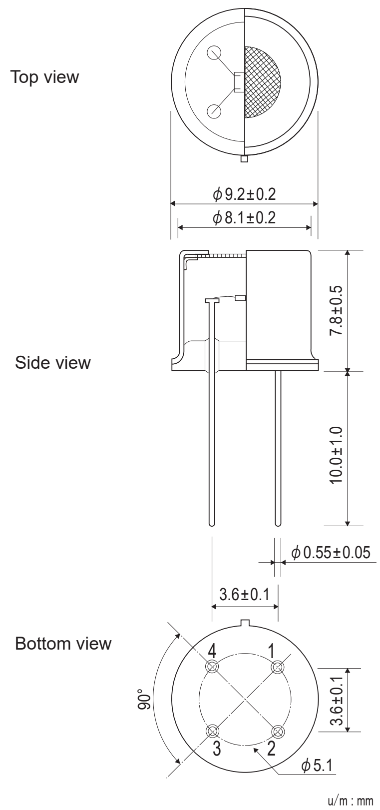
Item	Specification
Sensor resistance (100ppm hydrogen)	0.3kΩ ~ 3.0kΩ
Sensor resistance ratio (*β*)	0.25 ~ 0.60
β = Rs(1000ppm hydrogen)/Rs(100ppm hydrogen)	
Heater current (R_H)	56 ± 5mA
Heater power consumption (P_H)	approx. 280mW

NOTE 1: Sensitivity characteristics are obtained under the following standard test conditions:

(Standard test conditions)
Temperature and humidity: 20 ± 2°C, 65 ± 5% RH
Circuit conditions: V_c = 5.0±0.01V DC
V_H = 5.0±0.05V DC
R_L = 10.0kΩ ± 1%
Preheating period: 2 days or more under standard circuit conditions

All sensor characteristics shown in this brochure represent typical characteristics. Actual characteristics vary from sensor to sensor and from production lot to production lot. The only characteristics warranted are those shown in the Specification table above.

1-7 *Dimensions*



Pin connection:
1: Heater
2: Sensor electrode (-)
3: Sensor electrode (+)
4: Heater

Fig. 3 - Sensor dimensions

Mechanical Strength:

The sensor shall have no abnormal findings in its structure and shall satisfy the above electrical specifications after the following performance tests:

Withdrawal Force - (pin from base) withstand force of 5kg in each direction

Vibration - frequency-1000c/min., total amplitude-4mm, duration-one hour, direction-vertical

Shock - acceleration-100G, repeated 5 times

2. Typical Sensitivity Characteristics

2-1 *Sensitivity to various gases*

Figure 4 shows the relative sensitivity of TGS2616-C00 to various gases. The Y-axis shows the ratio of the sensor resistance in various gases (Rs) to the sensor resistance in 100ppm of hydrogen (Ro).

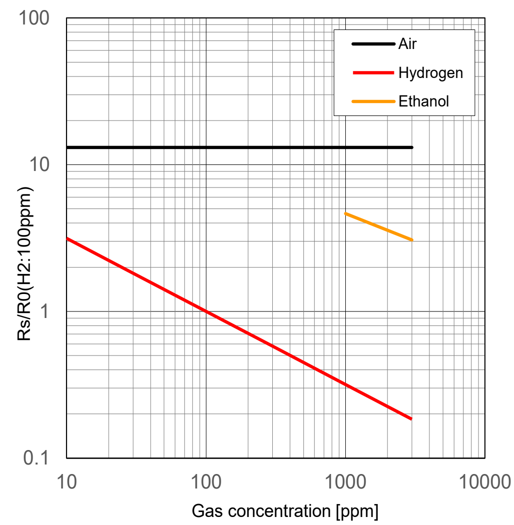


Fig. 4 - Sensitivity to various gases (Rs/Ro)

2-2 *Temperature and humidity dependency*

Figure 5 shows the temperature dependency of TGS2616-C00. The Y-axis shows the ratio of sensor resistance in 100ppm of hydrogen under various temperature conditions (Rs) to the sensor resistance in 100ppm of hydrogen at 20˚C/65%RH (R0).

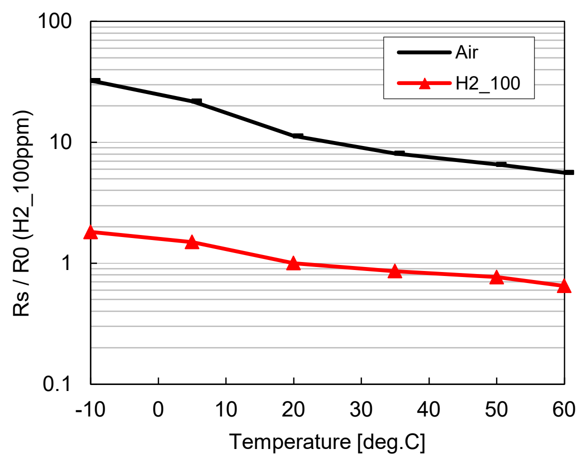


Fig.5 - Temperature dependency (Rs/R0)

Figure 6 shows the humiditye dependency of TGS2616-C00. The Y-axis shows the ratio of sensor resistance in 100ppm of hydrogen under various humidity conditions (Rs) to the sensor resistance in 100ppm of hydrogen at 20˚C/65%RH (R0).

For economical circuit design, a thermistor can be incorporated to compensate for temperature (*for additional information on temperature compensation in circuit designs, please refer to the Technical Advisory 'Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors'*).

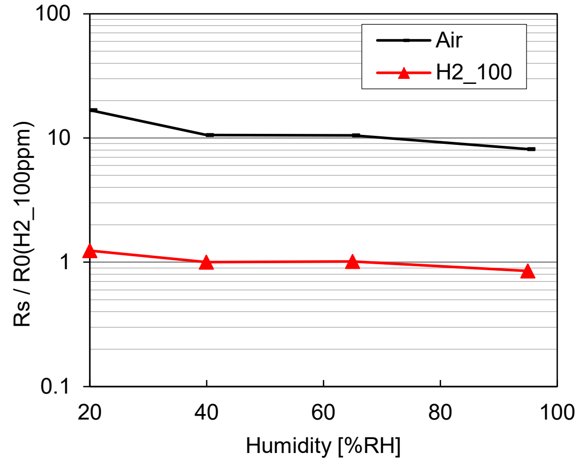


Fig.6 - Humidity dependency (Rs/R0)

2-3 *Gas response*

Figure 7 shows the change pattern of sensor resistance (Rs) when the sensor is inserted into and later removed from 10000ppm of hydrogen.

As these charts display, the sensor's response speed to the presence of gas is extremely quick, and when removed from gas, the sensor will recover back to its original value in a short period of time.

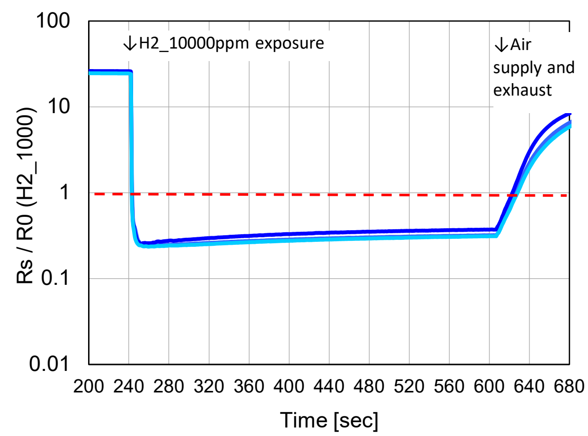


Fig. 7 - Gas response to hydrogen of TGS2616-C00

2-4 *Long-term characteristics*

Figure 8 shows long-term stability of TGS2616-C00 as measured for more than 700 days. The sensor is first energized in normal air. Measurement for confirming sensor characteristics is conducted under standard test conditions. The initial value of Rs was measured after two days energizing in normal air at the rated voltage. The Y-axis represents the sensor resistance in air, 100ppm of hydrogen, and 1000ppm of hydrogen.

The Rs in hydrogen is very stable over the test period.

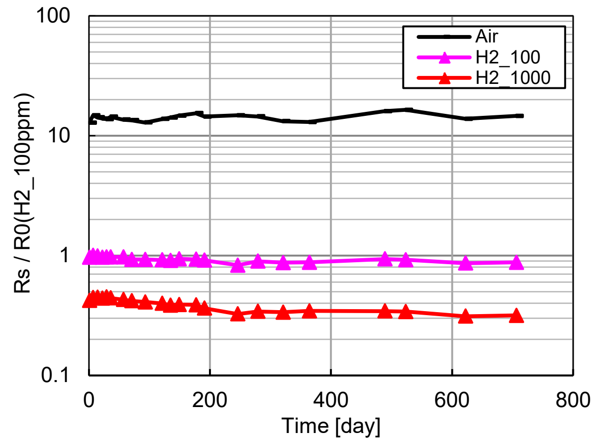


Fig. 8 - Long-term stability (continuous energizing) of TGS2616-C00

3 Cautions

3-1 *Situations which must be avoided*

1) Exposure to silicone vapors
If silicone vapors adsorb onto the sensor's surface, the sensing material will be coated, irreversibly inhibiting sensitivity. Avoid exposure where silicone adhesives, hair grooming materials, or silicone rubber/putty may be present.

2) Highly corrosive environment
High density exposure to corrosive materials such as H_2S, SOx, Cl_2, HCl, etc. for extended periods may cause corrosion or breakage of the lead wires or heater material.

3) Contamination by alkaline metals
Sensor drift may occur when the sensor is contaminated by alkaline metals, especially salt water spray.

4) Contact with water
Sensor drift may occur due to soaking or splashing the sensor with water.

5) Freezing
If water freezes on the sensing surface, the sensing material would crack, altering characteristics.

6) Application of excessive voltage
If higher than specified voltage is applied to the sensor or the heater, lead wires and/or the heater may be damaged or sensor characteristics may drift, even if no physical damage or breakage occurs.

7) Operation in zero/low oxygen environment
TGS sensors require the presence of around 21% (ambient) oxygen in their operating environment in order to function properly and to exhibit characteristics described in Figaro's product literature. TGS sensors cannot properly operate in a zero or low oxygen content atmosphere.

8) Polarization
These sensors have polarity. Incorrect Vc connection may cause significant deterioration of long term stability. Please connect Vc according to specifications.

9) Pin handling
Do not bend or twist the pins or twist the sensor cap when mounting the sensor on a circuit board or removing the sensor from a circuit board after soldering. If excessive stress is applied to the glass seal at the pin exit on the sensor base due to improper handling, the glass seal may be broken or damaged, which may result in deterioration of the sensor performance because poisonous gases or interference gases may enter the sensor housing through the broken glass seal.

3-2 *Situations to be avoided whenever possible*

1) Water condensation
Light condensation under conditions of indoor usage should not pose a problem for sensor performance. However, if water condenses on the sensor's surface and remains for an extended period, sensor characteristics may drift.

2) Usage in high density of gas
Sensor performance may be affected if exposed to a high density of gas for a long period of time, regardless of the powering condition.

3) Storage for extended periods
When stored without powering for a long period, the sensor may show a reversible drift in resistance according to the environment in which it was stored. The sensor should be stored in a sealed bag containing clean air; do not use silica gel. Note that as unpowered storage becomes longer, a longer preheating period is required to stabilize the sensor before usage.

4) Long term exposure in adverse environment
Regardless of powering condition, if the sensor is exposed in extreme conditions such as very high humidity, extreme temperatures, or high contamination levels for a long period of time, sensor performance will be adversely affected.

5) Vibration
Excessive vibration may cause the sensor or lead wires to resonate and break. Usage of compressed air drivers/ultrasonic welders on assembly lines may generate such vibration, so please check this matter.

6) Shock
Breakage of lead wires may occur if the sensor is subjected to a strong shock.

3-3 Sensor mounting

1) *Soldering*
Ideally, sensors should be soldered manually. However, wave soldering can be done under the following conditions:

a) Suggested flux: rosin flux with minimal chlorine

b) Speed: 1-2 meters/min.
c) Preheating temperature: 100±20˚C
d) Solder temperature: 250±10˚C
e) Up to two passes through wave soldering machine allowed

Results of wave soldering cannot be guaranteed if conducted outside the above guidelines since some flux vapors may cause drift in sensor performance similar to the effects of silicone vapors.

2) Printed wiring board design
The recommended land pattern of PWB for mounting a gas sensor is shown in Figure 9.

a) The insertion hole (φ0.8) for sensor lead pins should be a non-plated and non-through hole.
b) There should be no wiring pattern on the PWB surface on which the sensor will be mounted. Wiring patterns should only be designed on the opposite side of the PWB.
c) It is best to design a land pattern so that a sensor can easily be mounted on. The land pattern shown in Figure 9 is a recommended example only.

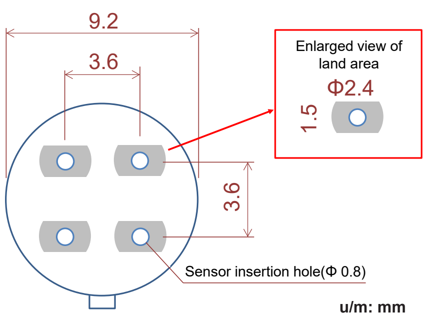


Fig. 9 - Recommended land pattern

NOTE: To achieve the optimal level of accuracy in gas detectors, each TGS2616-C00 sensor should be individually calibrated by matching it with a load resistor (RL) in an environment containing the target gas concentration for alarming (refer to Fig. 2).

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