

Technical Information for Air Quality Control Sensors

**FIGARO**

*an ISO9001 company*

The Figaro 8100 is a new MEMS-type semiconductor air quality sensor. Combining advanced Micro Electro Mechanical Systems technology (MEMS) with Figaro's extensive experience in metal oxide type gas sensing sensors, Figaro has developed a new indoor air quality sensor with extremely low power consumption and small size. With its excellent durability and stability, TGS8100 is ideal for applications such as air cleaners, air conditioners and ventilation fan activation in home and office settings.



	<i>Page</i>
<i>Specifications</i>	
Features.....	2
Applications.....	2
Structure.....	2
Basic measuring circuit.....	2
Circuit & operating conditions.....	3
Specifications.....	3
Dimensions.....	3
Driving conditions.....	4
<i>Basic Sensitivity Characteristics</i>	
Sensitivity to various gases.....	4
Temperature and humidity dependency.....	5
Gas response.....	5
Initial action.....	6
Long term characteristics.....	6
Effects of air flow.....	7
Durability to HMDS.....	7
Soldering conditions.....	8
Packaging method.....	8
<i>Cautions</i> .....	9

**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 SENSOR HAS NOT BEEN SPECIFICALLY TESTED BY FIGARO.

## 1. Specifications

### 1-1 Features

- \* Surface mount package
- \* Low power consumption
- \* High sensitivity to cigarette smoke, cooking odors, and gaseous air contaminants
- \* Long life
- \* Low cost

### 1-2 Applications

- \* Indoor air quality monitors
- \* Air cleaners
- \* Ventilation control
- \* Kitchen range hood control

### 1-3 Structure

Figure 1 shows the structure of TGS8100. The MEMS chip contains a sensor element with heater. The sensor's (+) electrode is connected to pin No.3 and the (-) electrode is connected to pin No.2. The sensing material is heated by a heater connected to pins No.1 and No.4. Lead wires are Au and connected to sensor pad which is also made of Au. The sensor base is made of alumina. The sensor cap is made of 42 alloy and contains 2 pin holes on the sensor's top.

### 1-4 Basic measuring circuit

Figure 2 shows the basic measuring circuit. The sensor requires two voltage inputs: heater voltage (VH) and circuit voltage (VC). The heater voltage (VH) is applied to the integrated heater in order to maintain the sensing element at a specific temperature which is optimal for sensing. Circuit voltage (VC) is applied to allow measurement of voltage (VOUT) across a load resistor (RL) which is connected in series with the sensor. DC voltage is required for the circuit voltage since the sensor has a polarity. The value of the load resistor (RL) should be chosen to optimize the alarm threshold value.

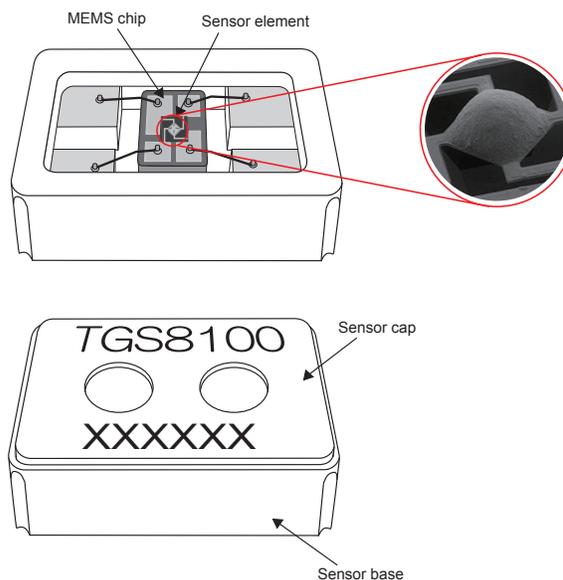


Fig. 1 - Sensor structure

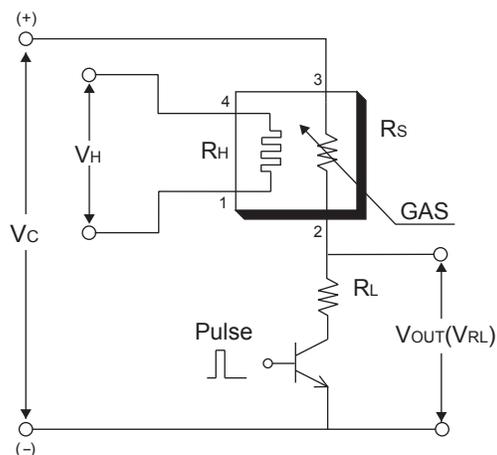


Fig. 2 - Basic measuring circuit

Sensor resistance (Rs) is calculated with a measured value of VOUT(VRL) by using the following formula:

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

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 <sub>C</sub> )	max 3.0V DC for 2msec 0V for 998msec
Heater voltage (V <sub>H</sub> )	1.8V DC±2% (NOTE 3)
Heater resistance (room temp)	110Ω (typical)
Load resistance (R <sub>L</sub> )	variable (10kΩ min.)
Operating & storage temperature	-10°C ~ +50°C
Optimal detection concentration	1 ~ 30ppm H <sub>2</sub>

1-6 Specifications NOTE 1

Item	Specification
Sensor resistance (air)	10kΩ ~ 300kΩ
Sensor resistance gradient (β)	~ 0.6
$\beta = R_s(10\text{ppm hydrogen})/R_s(\text{air})$	
Heater current (R <sub>H</sub> )	84mA (typical)
Heater power consumption (P <sub>H</sub> )	15mW (typical)

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

*(Standard test conditions)*

Temperature and humidity: 20 ± 2°C, 65 ± 5% RH

Preheating period: 1 hour or more under standard circuit conditions.

**NOTE 2:** TGS8100 is an ESD-sensitive device. Figaro recommends using ESD protection equipment for handling the sensor.

**NOTE 3:** Please regulate heater voltage as specified in the above table. Sensor performance may differ from that shown in this brochure if specified heater voltage is not maintained.

*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

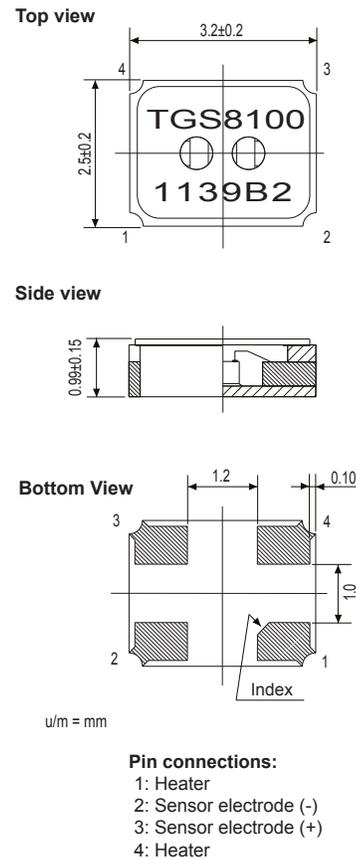


Fig. 3 - Sensor dimensions

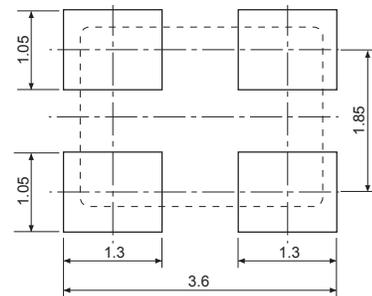


Fig. 4 - Recommended land pattern

**Mechanical Strength:**

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

**Vibration** - frequency-10~55Hz, total amplitude-1.5mm, duration-two hours, direction-X Y Z

**Drop** - 50 times from 1m height onto a tile floor

VH: 1.8V (Continuous energizing)

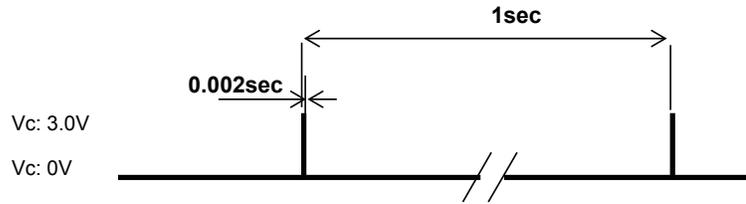


Fig. 5 - Driving conditions of TGS8100

## 2. Basic Sensitivity Characteristics

### 2-1 Sensitivity to various gases

Figure 6 shows the relative sensitivity of TGS8100 to various gases. The Y-axis shows the ratio of the sensor resistance in various gases ( $R_s$ ) to the sensor resistance in clean air ( $R_o$ ) taken at standard test conditions of 20°C/65%RH.

Figure 7 shows the relative sensitivity of TGS8100 to various gases in cigarette smoke. The Y-axis shows the ratio of the sensor resistance in cigarette smoke ( $R_s$ ) to the sensor resistance in clean air ( $R_o$ ) taken at standard test conditions of 20°C/65%RH. This data was taken in a 20m<sup>3</sup> room with cigarettes placed on a flat surface. The burning time for one cigarette was approximately 8 minutes. (Note: Generally, the activation point for an air cleaner would be around  $R_s/R_o=0.85$ , while the  $R_s/R_o$  for just one cigarette is as low as 0.65, making this sensor ideal for air cleaner application).

This data shows that TGS8100 has good sensitivity to low concentrations of air contaminants, including those found in cigarette smoke.

**NOTE:**

All sensor characteristics in this technical brochure represent typical sensor characteristics.

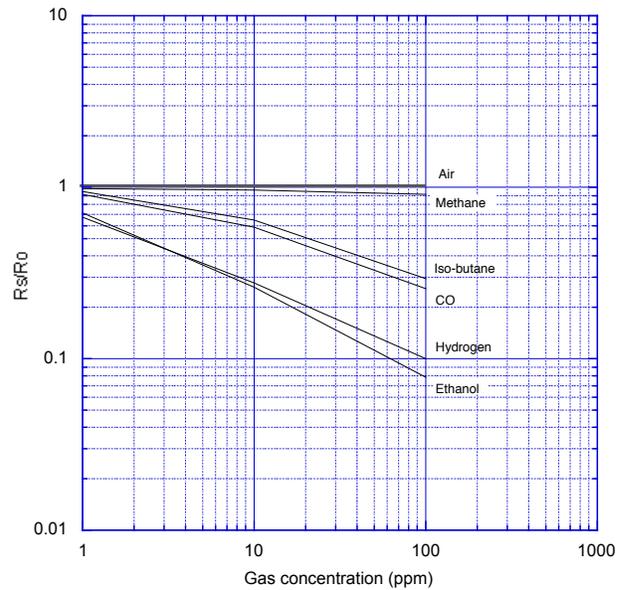


Fig. 6 - Sensitivity to various gases ( $R_s/R_o$ )

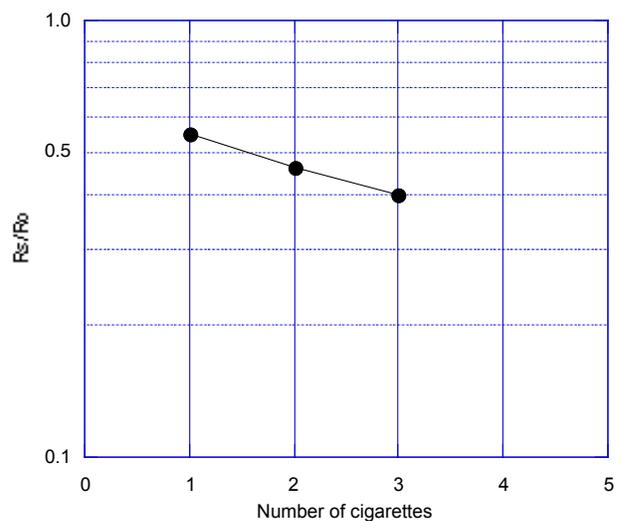


Fig. 7 - Sensitivity to cigarette smoke ( $R_s/R_o$ )

2-2 Temperature and humidity dependency

Figure 8 shows the temperature and humidity dependency of TGS8100 in clean air. The Y-axis shows the ratio of sensor resistance in clean air under various atmospheric conditions ( $R_s$ ) to the sensor resistance in clean air at 20°C/65%RH ( $R_o$ ).

RH (°C)	40%RH	65%RH	85%RH	100%RH
-10				1.46
0				1.21
10	1.28	1.15	1.08	
20	1.11	1.00	0.94	
30	0.98	0.87	0.82	
40	0.87	0.78	0.73	
50	0.78	0.69	0.65	

Table 1 - Temperature and humidity dependency (typical values of  $R_s/R_o$  for Fig. 8)

Table 1 shows a table of values of the sensor's resistance ratio ( $R_s/R_o$ ) under the same conditions as those used to generate Figure 8.

2-3 Gas response

Figure 9 shows the response pattern of the sensor when inserted into and later removed from 10ppm of hydrogen after a 3 minute period. The Y-axis shows the ratio of sensor resistance over time ( $R_s$ ) compared with sensor resistance in clean air just prior to insertion into hydrogen ( $R_o$ ).

As this chart indicates, 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.

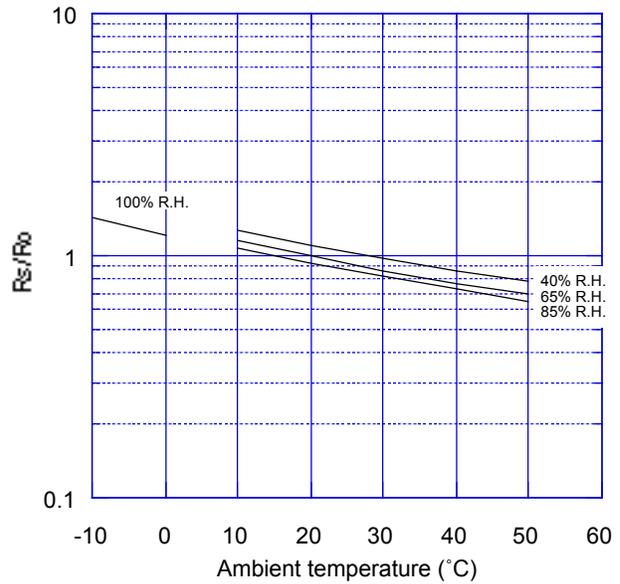


Fig. 8 - Temperature and humidity dependency ( $R_s/R_o$ ) in clean air

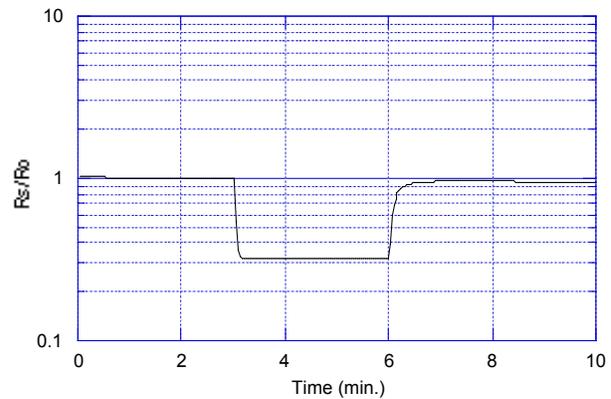


Fig. 9 - Gas response to hydrogen

2-4 Initial action

Figure 10 shows the initial action of the sensor resistance ( $R_s$ ) for a sensor which is stored unenergized in normal air for 7 days and then energized in clean air. The Y-axis represents sensor resistance in clean air at various times after energizing ( $R_s$ ) compared with sensor resistance 20 min. after energizing ( $R_o$ ).

The  $R_s$  drops sharply for the first seconds after energizing, regardless of the presence of gases, and then reaches a stable level according to the ambient atmosphere. Such behavior during the warm-up process is called "Initial Action".

Since this 'initial action' may cause an air cleaner to activate unnecessarily during the initial moments after powering on, it is recommended that an initial delay circuit be incorporated into the device's design.

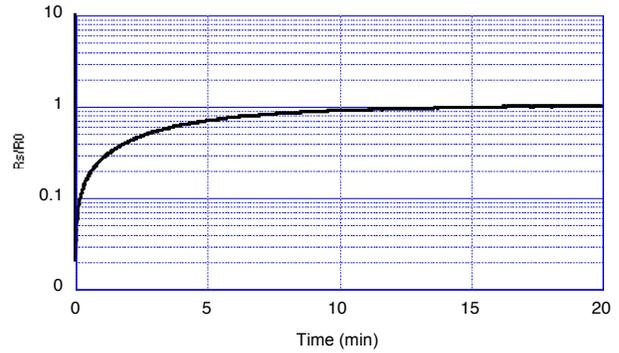


Fig. 10 - Initial action

2-5 Long-term characteristics

Figures 11-12 show the long-term stability of TGS8100 as measured for more than 250 days. In Figures 11 & 12, the sensor is first energized in normal air. Measurement for confirming sensor characteristics is conducted under standard test conditions. Figure 11 depicts sensor resistance in clean air over the test period, while in Figure 12 the Y-axis shows the ratio of sensor resistance in gases ( $R_s$ ) compared with sensor resistance in fresh air on the same day ( $R_o$ ).

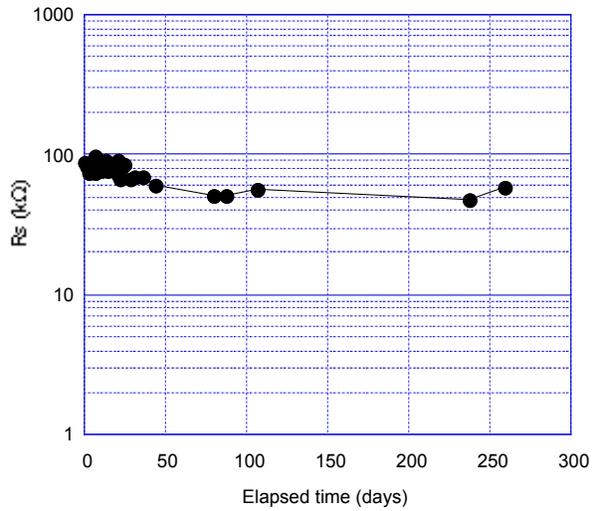


Fig. 11 - Long-term stability (continuous energizing) in clean air

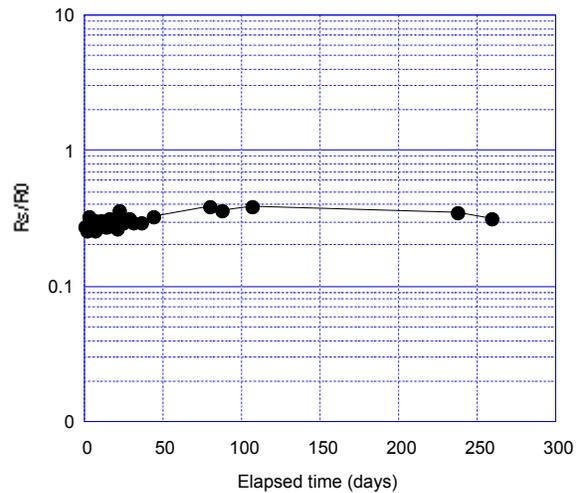


Fig. 12 - Long term stability (continuous energizing) in 10ppm H<sub>2</sub>

2-6 Effects of air flow

Fig. 14 charts how the sensor is affected by an air flow that is generated as illustrated in Fig. 13. This data demonstrates that there is no significant influence on the sensor by an air flow of 7.6m/sec.

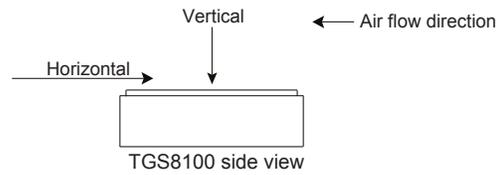


Fig. 13 - Air flow test direction

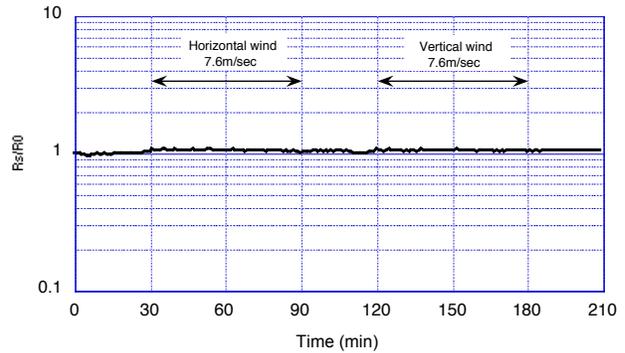


Fig. 14 - Effect of air flow

2-7 Durability to HMDS

Figure 15 shows the effects on TGS8100 of silicone vapor exposure. Sensor resistance prior to HMDS (hexamethyldisiloxane) gas exposure was measured. Energized sensors were placed into an environment of 20°C/50%RH. In this environment, the sensors were exposed to 10 ppm of HMDS. When measuring sensor resistance, sensors were returned to normal air for 1 hour. After the measurement for 1 hour, the sensors were returned to HMDS exposure.

In Fig.15a, the Y-axis shows the sensor resistance in 10ppm hydrogen and air. In Fig.15b, the Y-axis shows the ratio of sensor resistance in 10ppm hydrogen ( $R_s$ ) compared with sensor resistance in fresh air on the same day ( $R_0$ ). As Fig.15a shows, both sensor resistance ( $R_s$ ) in air and in 10 ppm of hydrogen decreased for the first 10 minutes of exposure to 10ppm HMDS. However, as Fig.15b shows, there is no significant change in  $R_s/R_0$ .

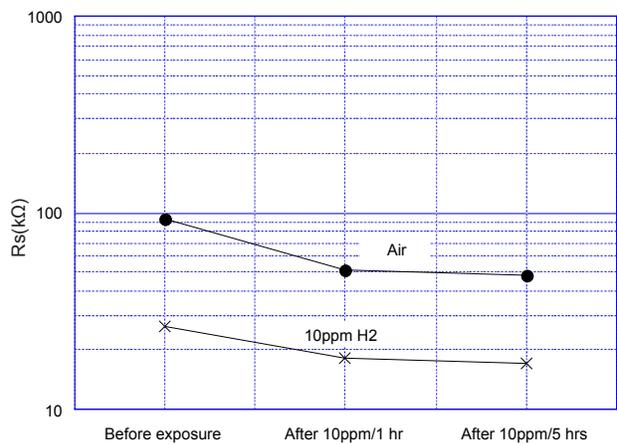


Fig. 15a - Effect of HMDS exposure ( $R_s$ )

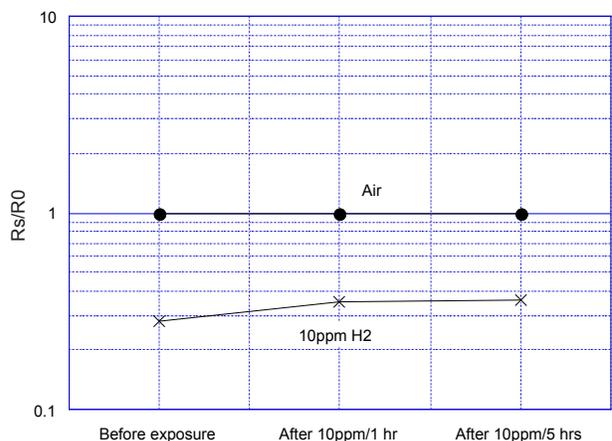


Fig. 15b - Effect of HMDS exposure ( $R_s/R_0$ )

## 2-8 Soldering conditions

Figaro has confirmed that reflow soldering can be done under the conditions shown in Table 2. If different soldering conditions are desired, users should conduct a test before production starts to see if there would be any adverse influence to sensor characteristics.

Preheat	Temperature	130~160°C	150~180°C
	Period	41 sec	60~120 sec
Main heat 1	Temperature	170°C	
	Period	123.5 sec	
Main heat 2	Temperature	225°C	235~245°C
	Period	16.5 sec	30~60 sec
Peak temperature of main heat		231.5°C	
Ambient gas		Nitrogen	

Table 2 - Reflow soldering conditions

## 2-9 Packing Method

Fig. 16 shows the structure of standard packaging for TGS8100. Figs. 17 and 18 show the dimensions of the packaging tape and reels.

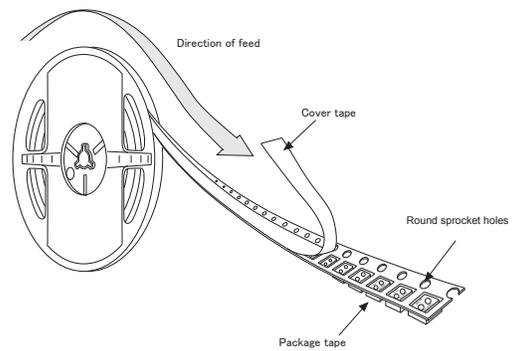


Fig. 16 - TGS8100 packaging structure

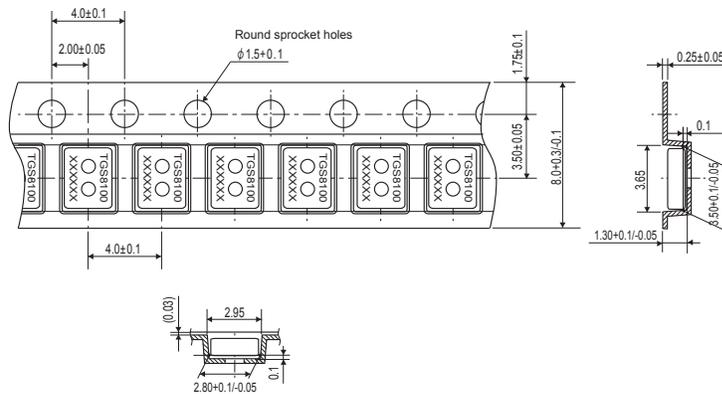


Fig. 17 - Dimensions of packaging tape

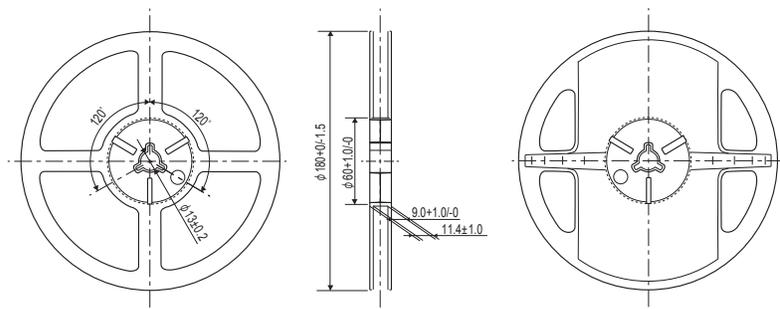


Fig. 18 - Dimensions of tape reel

### 3 Cautions on Usage of Figaro Gas Sensors

#### 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<sub>2</sub>S, SO<sub>x</sub>, Cl<sub>2</sub>, 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 V<sub>c</sub> connection may cause significant deterioration of long term stability. Please connect V<sub>c</sub> according to specifications.

#### 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.

##### 7) Influence by static electricity

TGS8100 is an ESD-sensitive device. Figaro recommends using ESD protection equipment for handling the sensor.

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