TGS 2610 - for the detection of Combustible Gases

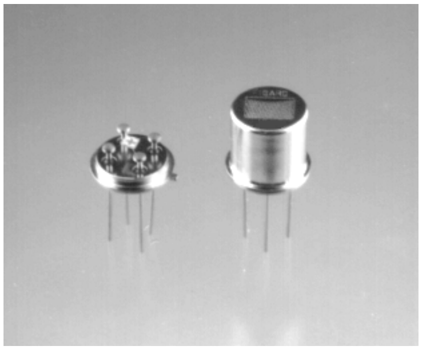
Features:

* General purpose sensor with sensitivity to wide variety of combustible gas
* Low power consumption
* High sensitivity to methane, propane, and butane
* Long life and low cost
* Uses simple electrical circuit

Applications:

* Domestic gas leak detectors and alarms
* Portable gas detectors
* Combustible gas and vapor detection

The sensing element is comprised of a metal oxide semiconductor layer formed on an alumina substrate of a sensing chip together with an integrated heater. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to the gas concentration.



The **TGS 2610** has high sensitivity to propane, methane, and butane, making it ideal for natural gas and LPG monitoring. The sensor can detect a wide range of gases, making it an excellent, low cost sensor for a variety of applications.

Due to miniaturization of the sensing chip, TGS 2610 requires a heater current of only 56mA and the device is housed in a standard TO-5 package.

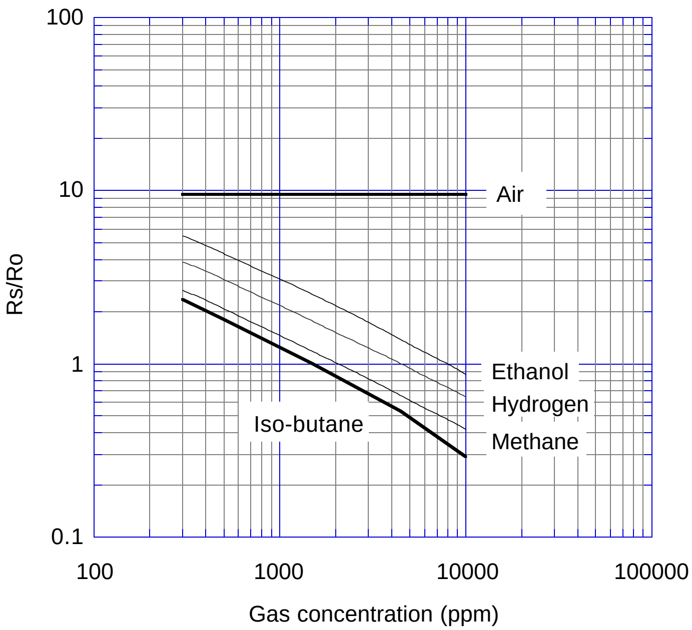
The figure below represents typical sensitivity characteristics, all data having been gathered at standard test conditions (see reverse side of this sheet). The Y-axis is indicated as *sensor resistance ratio* (Rs/Ro) which is defined as follows:

Rs = Sensor resistance in displayed gases at various concentrations
Ro = Sensor resistance in 1500ppm of iso-butane

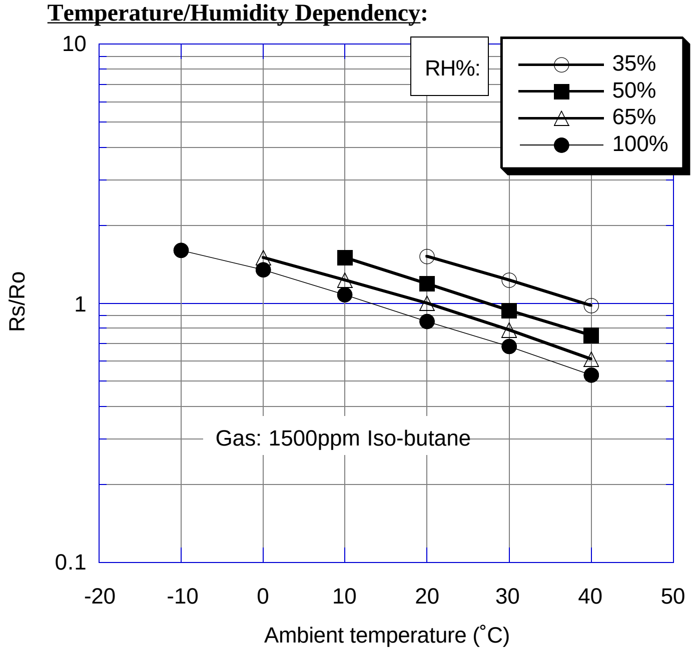
The figure below represents typical temperature and humidity dependency characteristics. Again, the Y-axis is indicated as *sensor resistance ratio* (Rs/Ro), defined as follows:

Rs = Sensor resistance at 1500ppm of iso-butane at various temperatures/humidities
Ro = Sensor resistance at 1500ppm of iso-butane at 20°C and 65% R.H.

Sensitivity Characteristics:



Temperature/Humidity Dependency:

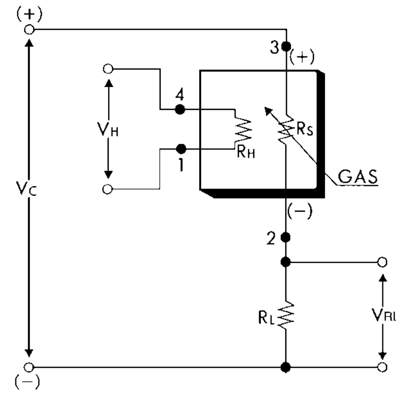


IMPORTANT NOTE: OPERATING CONDITIONS IN WHICH FIGARO SENSORS ARE USED WILL VARY WITH EACH CUSTOMER'S SPECIFIC APPLICATIONS. FIGARO STRONGLY RECOMMENDS CONSULTING OUR TECHNICAL STAFF BEFORE DEPLOYING FIGARO SENSORS IN YOUR APPLICATION AND, IN PARTICULAR, WHEN CUSTOMER'S TARGET GASES ARE NOT LISTED HEREIN. 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.

Basic Measuring Circuit:

The sensor requires two voltage inputs: heater voltage (V_H) and circuit voltage (V_C). The heater voltage (V_H) is applied to the integrated heater in order to maintain the sensing element at a specific temperature which is optimal for sensing. Circuit voltage (V_C) is applied to allow measurement of voltage (V_{RL}) across a load resistor (R_L) which is connected in series with the sensor.

A common power supply circuit can be used for both V_C and V_H to fulfill the sensor's electrical requirements. The value of the load resistor (R_L) should be chosen to optimize the alarm threshold value, keeping power dissipation (P_S) of the semiconductor below a limit of 15mW. Power dissipation (P_S) will be highest when the value of Rs is equal to R_L on exposure to gas.



Specifications:

Model number			TGS 2610	
Sensing element type			D1	
Standard package			TO-5 metal can	
Target gases			Combustible gases	
Typical detection range			500 ~ 10,000 ppm	
Standard circuit conditions	Heater Voltage	V_H	5.0±0.2V DC/AC	
	Circuit voltage	V_C	5.0±0.2V DC	$P_S \leq 15mW$
	Load resistance	R_L	Variable	$P_S \leq 15mW$
Electrical characteristics under standard test conditions	Heater resistance	R_H	approx. 59Ω at room temp.	
	Heater current	I_H	56 ± 5mA	
	Heater power consumption	P_H	280mW	VH = 5.0V DC
	Sensor resistance	Rs	1 ~ 5 kΩ in 1500ppm iso-butane	
	Sensitivity (change ratio of Rs)		0.53 ± 0.05	$\frac{Rs\ (4500ppm)}{Rs\ (1500ppm)}$
Standard test conditions	Test gas conditions		Iso-butane vapor in air at 20±2°C, 65±5%RH	
	Circuit conditions		V_C = 5.0±0.01V DC V_H = 5.0±0.05V DC	
	Conditioning period before test		7 days	

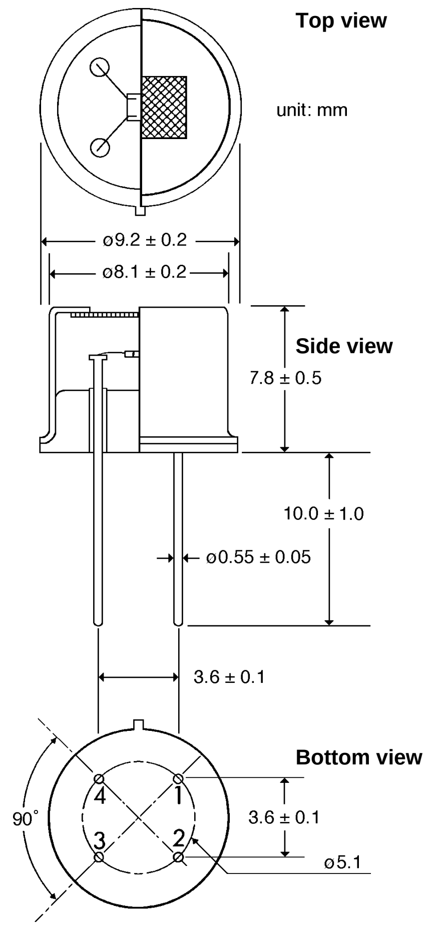
The value of power dissipation (P_S) can be calculated by utilizing the following formula:

$$P_S = \frac{(V_C - V_{RL})^2}{R_S}$$

Sensor resistance (Rs) is calculated with a measured value of V_{RL} by using the following formula:

$$R_S = \frac{V_C - V_{RL}}{V_{RL}} \times R_L$$

Structure and Dimensions:



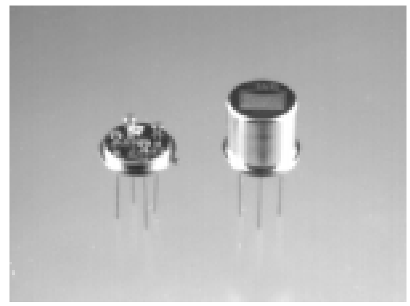
Pin connection:
1 : Heater
2 : Sensor electrode (-)
3 : Sensor electrode (+)
4 : Heater

FIGARO

an ISO9001 company

Technical Information for Combustible Gas Sensors

The Figaro 2600 series is a new type thick film metal oxide semiconductor, screen printed gas sensor which offers miniaturization and lower power consumption. The TGS2610 displays high selectivity and sensitivity to LP Gas and methane.



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

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1. Specifications

1-1 *Features*

* High selectivity to LP gas and methane
* Low power consumption
* Small size
* Long life

1-2 *Applications*

* Domestic gas leak detectors
* Recreational vehicle gas leak detectors

1-3 *Structure*

Figure 1 shows the structure of TGS2610. Using thick film techniques, the sensing material is printed on electrodes (Au) which have been printed onto an alumina substrate. The main material of the sensing element is tin dioxide (SnO_2). 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 8% of 0.04mm diameter and are spot welded to sensor pins which are made of Ni-plated Ni-Fe 50%.

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

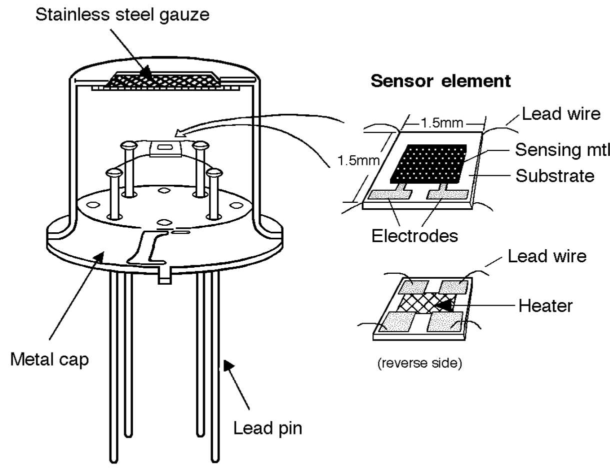

Fig. 1 - Sensor structure

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. DC voltage is always required for the circuit voltage. The sensor signal (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.

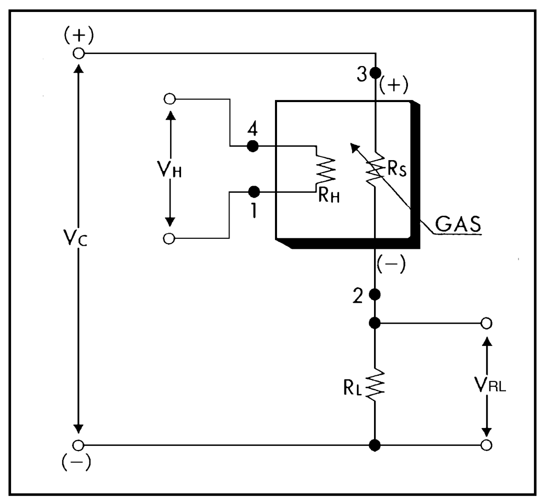

Fig. 2 - Basic measuring circuit

$$Rs = \frac{Vc - V_{RL}}{V_{RL}} \times R_L$$

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 (Vc)	5.0V ± 0.2V DC
Heater voltage (VH)	5.0V ± 0.2V DC/AC
Heater resistance (room temp.)	approx. 59Ω
Load resistance (RL)	Variable
Sensor power dissipation (Ps)	less than 15mW
Operating & storage temperature	-40˚C ~ +70˚C
Optimal detection concentration	500 ~ 10,000ppm

1-6 *Specifications* **NOTE 1**

Item	Specification
Sensor resistance (1500ppm iso-butane)	1kΩ ~ 5kΩ
Sensor resistance gradient (β)	0.53 ± 0.05
β = Rs(4500ppm iso-butane)/Rs(1500ppm iso-butane)	
Heater current	56 ± 5mA
Heater power consumption	approx. 280mW

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 - withstand force > 5kg in each direction

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

Shock - acceleration-100G, repeated 5 times

1-7 *Dimensions*

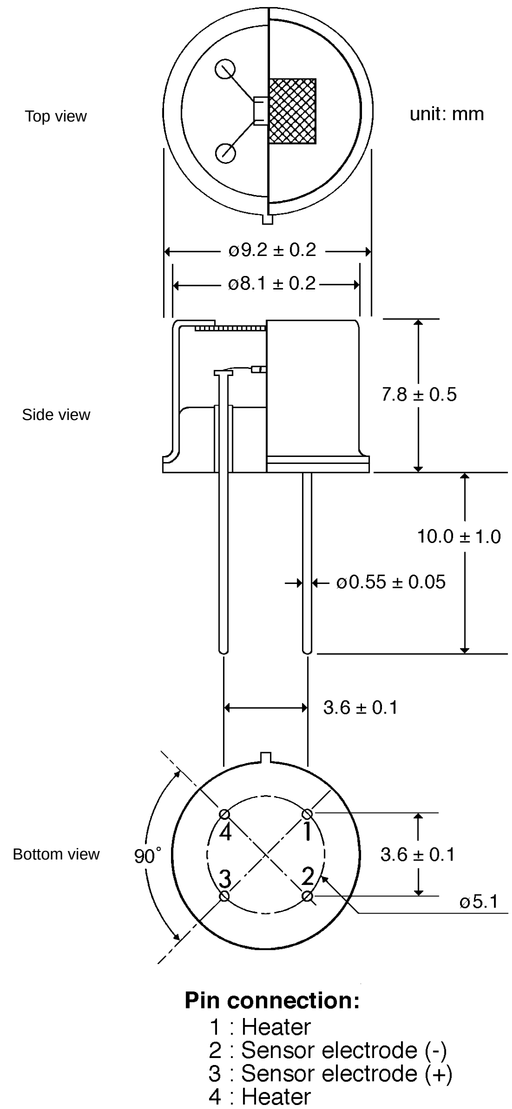

Fig. 3 - Sensor dimensions

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: Vc = 5.0±0.01V DC
VH = 5.0±0.05V DC
RL = 4.0kΩ ± 1%
Preheating period: 7 days or more under standard circuit conditions

2. Basic Sensitivity Characteristics

2-1 *Sensitivity to various gases*

Figure 4 shows the relative sensitivity of TGS2610 to various gases. The Y-axis shows the ratio of the sensor resistance in various gases (Rs) to the sensor resistance in 1500ppm of iso-butane (Ro).

The sensitivity to ethanol, which may act as an interference gas, is lower compared with that of iso-butane or methane.

Using the basic measuring circuit illustrated in Fig. 2, these sensitivity characteristics provide the sensor output voltage (VRL) change as shown in Figure 5.

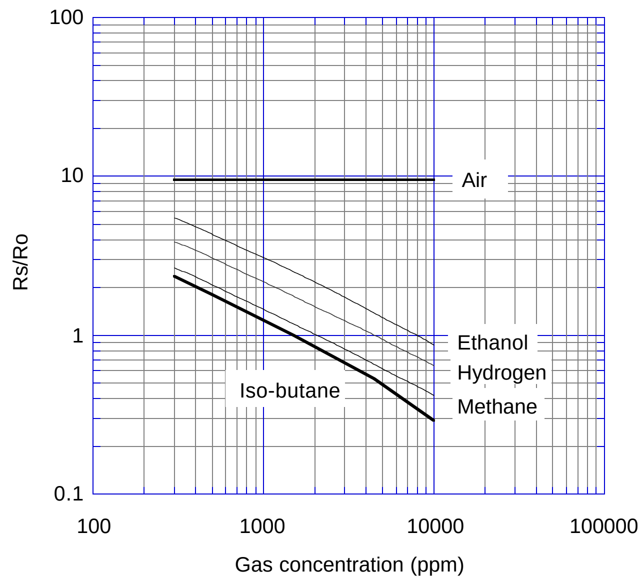

Fig. 4 - Sensitivity to various gases (Rs/Ro)

NOTE:
All sensor characteristics in this technical brochure represent typical sensor characteristics. Since the Rs or output voltage curve varies from sensor to sensor, calibration is required for each sensor (*for additional information on calibration, please refer to the Technical Advisory 'Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors'*).

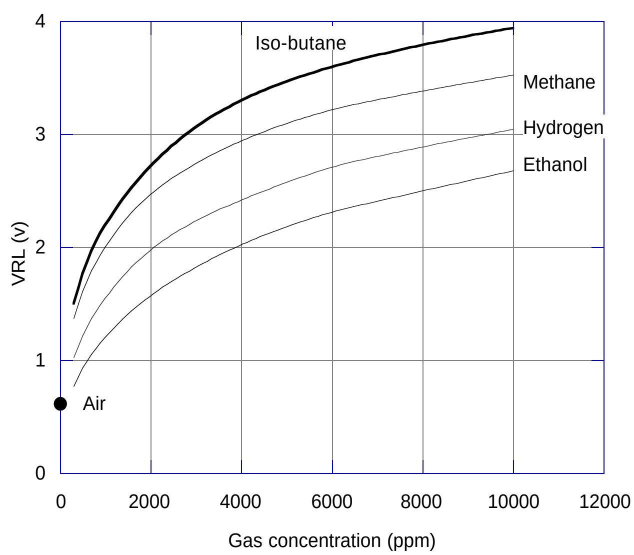

Fig. 5 - Sensitivity to various gases (VRL)

2-2 *Temperature and humidity dependency*

Figure 6 shows the temperature and humidity dependency of TGS2610. The Y-axis shows the ratio of sensor resistance in 1500ppm of iso-butane under various atmospheric conditions (Rs) to the sensor resistance in 1500ppm of iso-butane at 20˚C/65%RH (Ro).

R.H. / (˚C)	35%R.H.	50%R.H.	65%R.H.	95%R.H.
-10				1.60
0			1.50	1.35
10		1.50	1.23	1.08
20	1.52	1.19	1.00	0.85
30	1.23	0.94	0.79	0.68
40	0.98	0.75	0.61	0.53

Table 1 - Temperature and humidity dependency
(typical values of Rs/Ro for Fig. 6)

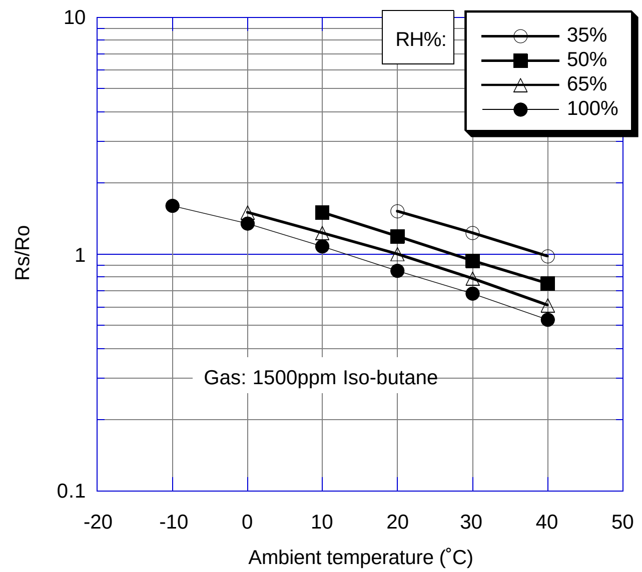

Fig. 6 - Temperature and humidity dependency (Rs/Ro)

Table 1 shows a table of values of the sensor's resistance ratio (Rs/Ro) under the same conditions as those used to generate Figure 6.

Figure 7 shows the sensitivity curve for TGS2610 to iso-butane under several ambient conditions. While temperature may have a large influence on absolute Rs values, this chart illustrates the fact that effect on the slope of sensor resistance ratio (Rs/Ro) is not significant. As a result, the effects of temperature on the sensor can easily be compensated.

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'*).

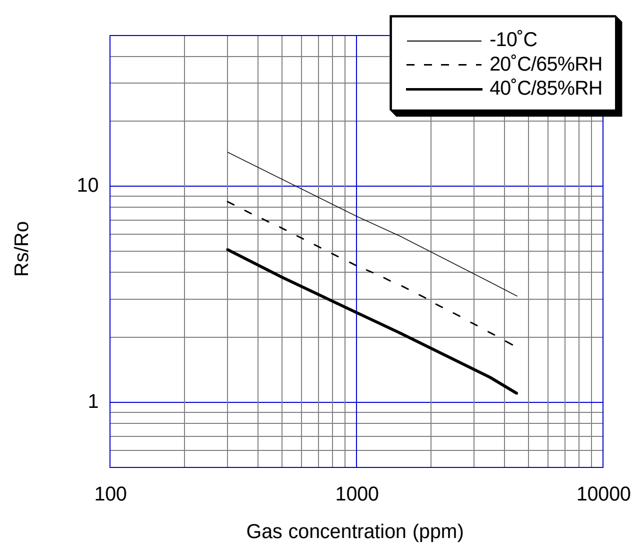

Fig. 7 - Resistance change ratio
under various ambient conditions

2-3 *Heater voltage dependency*

Figure 8 shows the change in the sensor resistance ratio according to variations in the heater voltage (VH).

Note that 5.0V as a heater voltage must be maintained because variance in applied heater voltage will cause the sensor's characteristics to be changed from the typical characteristics shown in this brochure.

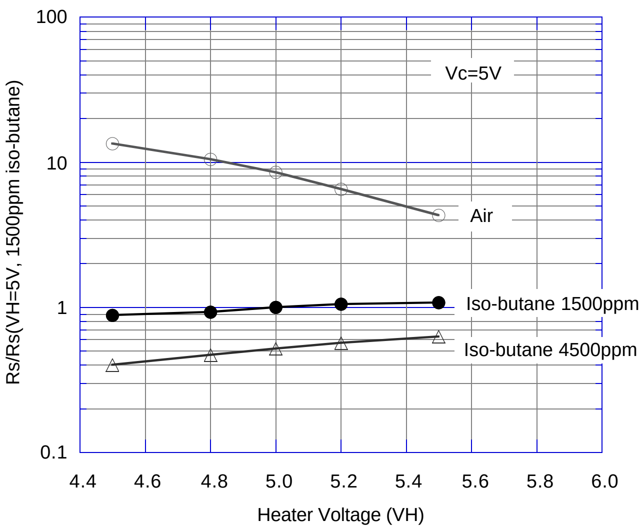

Fig. 8 - Heater voltage dependency (Vc=5.0)

2-4 *Circuit voltage dependency*

Figure 9 shows the change in the sensor resistance ratio resulting from variation in circuit voltage (Vc).

As shown here, using a Vc higher than the 5.0V specified in *Section 1-5* may result in the sensor diverging from Ohmic behavior and thus altering its characteristics from those shown as typical in this brochure.

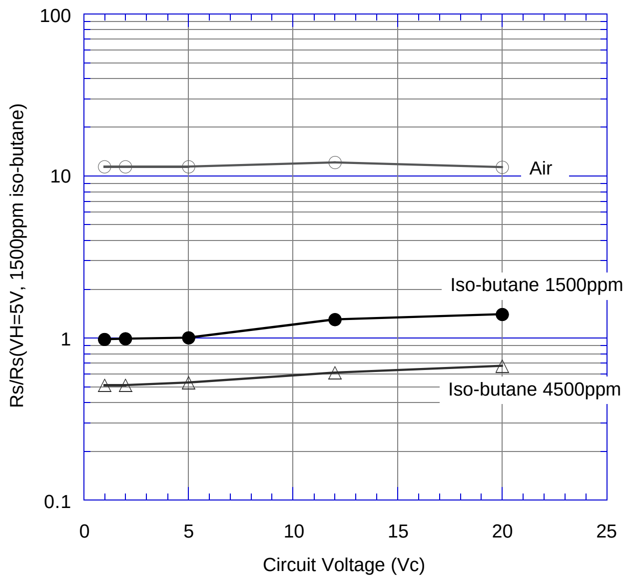

Fig. 9 - Circuit voltage dependency (VH=5.0)

2-5 *Gas response*

Figure 10 shows the change pattern of sensor resistance (Rs) when the sensor is inserted into and later removed from 1500ppm of iso-butane.

As this chart displays, 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.

Figure 11 demonstrates the sensor's repeatability by showing multiple exposures to a 1500ppm concentration of iso-butane. Unlike the test done for Fig. 10, here the sensor is located in a single environment which is exchanged periodically. As a result, though the process of gas diffusion reduces sensor response speed, good repeatability can be seen.

2-6 *Initial action*

Figure 12 shows the initial action of the sensor resistance (Rs) for a sensor which is stored unenergized in normal air for 30 days and later energized in clean air.

The Rs 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 a detector to alarm unnecessarily during the initial moments after powering on, it is recommended that an initial delay circuit be incorporated into the detector's design (*refer to Technical Advisory 'Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors'*). This is especially recommended for intermittent-operating devices such as portable gas detectors.

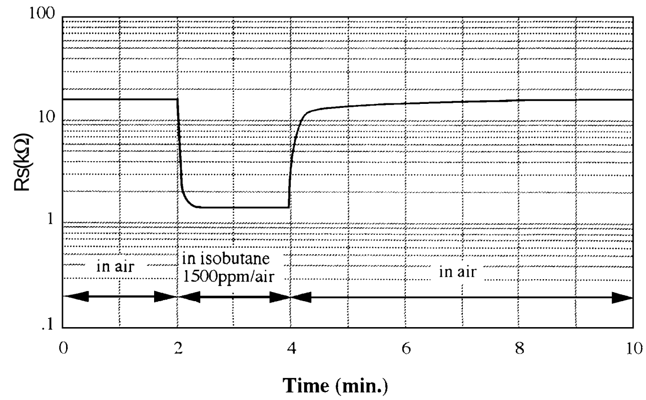

Fig. 10 - Gas response to iso-butane

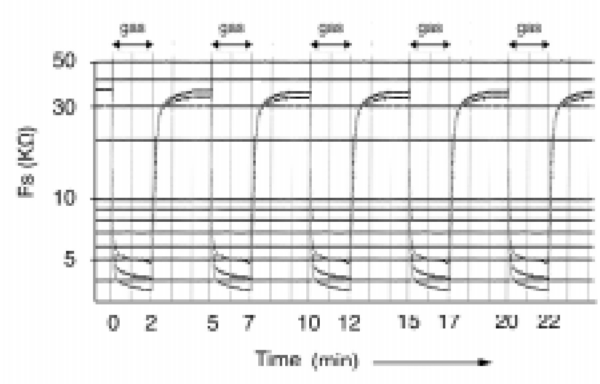

Fig. 11 - Repeatability

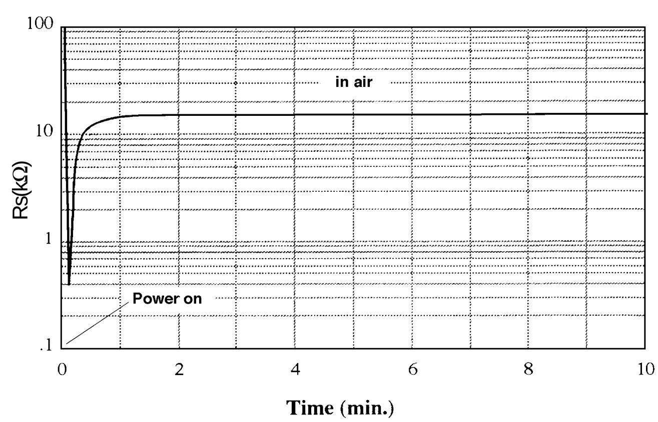

Fig. 12 - Initial action

2-7 *Long-term characteristics*

Figure 13 shows long-term stability of TGS2610 as measured for more than 500 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, 3500ppm of methane, 1500ppm of iso-butane, and 3500ppm of hydrogen.

The Rs in both iso-butane and methane is very stable over the test period.

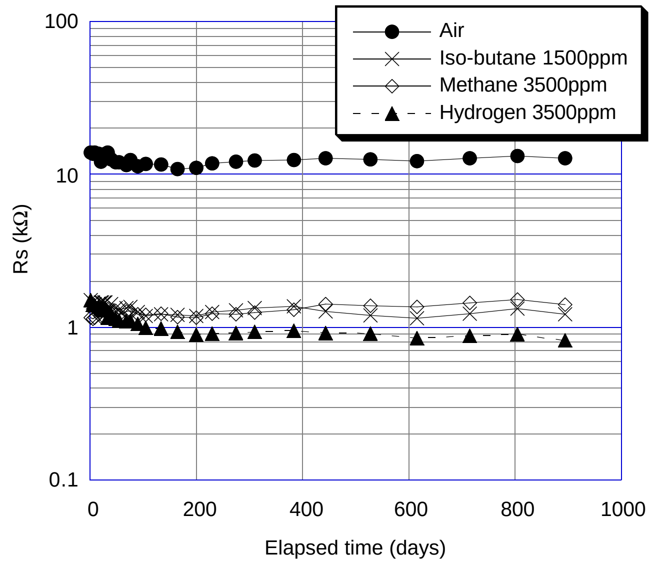

Fig. 13 - Long-term stability (continuous energizing)

Figure 14 shows the influence of storage in an unenergized condition on the sensor's resistance. The sensors were stored unenergized in air after 20 days energizing, then energized for one hour before a measurement was taken.

As the charts presented in this section illustrate, the sensor shows stable long term characteristics.

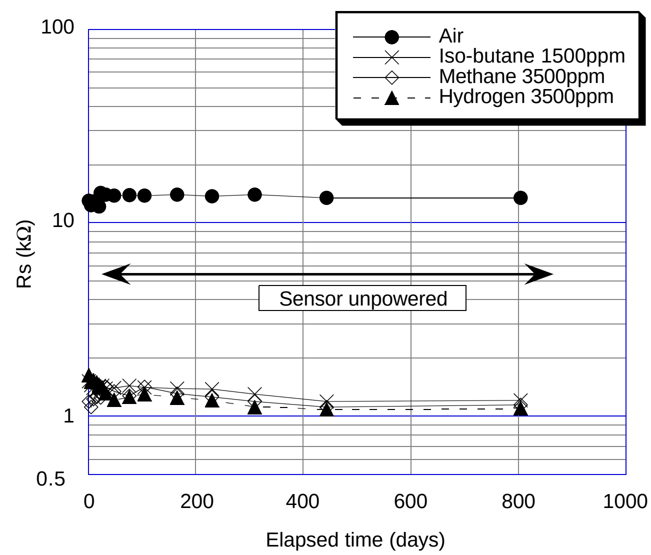

Fig. 14 - Influence of unenergizing

3. Reliability

3-1 *Gas exposure test #1*

Figure 15 shows the test procedure of short-term high concentration exposure to iso-butane gas. During this test, the sensor was kept energized under standard circuit conditions. The sensor resistance in both 1500ppm and 4500ppm of iso-butane was measured during 4 minute periods before and after the gas exposures (runs #1~12). All exposures in gas during this test were followed by exposure in normal air.

The gas exposure conditions were 4500ppm for 10 minutes, 9000ppm for 10 minutes, 1.5% (15000ppm) for 10 minutes, and 1.5% for 30 minutes. A second 30 minute exposure in 1.5% was done, but with V_H set equal to 6.0V.

Two days elapsed before test run #11 was completed. After this, sensors were energized in normal air for 3 days before run #12 for checking long-term effects.

Heater resistance at room temperature was also measured after gas exposure in order to check for the influence of high gas exposure.

The test results are shown in Figs. 16 and 17. The 1.5% iso-butane exposure while V_H=5.0V appeared to increase sensor resistance in gas temporarily (run #8~9). Increasing heater voltage to 6.0V during 1.5% exposure caused an increase in heater resistance, resulting in decreased sensor resistance in gas. In this case, the heater resistance did not recover to its original value (run #10~12).

As this section illustrates, exposure to iso-butane itself will cause a transitory effect from which the sensor can recover. However, high intensity exposure, coupled with higher than standard heater voltage, will cause a permanent change in heater resistance due to combustion of gas on the surface of the heater material at elevated heater voltage. Note that this phenomenon would not occur when elevated heater voltage is applied in fresh air (see Figure 22). In addition, sensor characteristics may also be altered due to combustion on the surface of the sensing material.

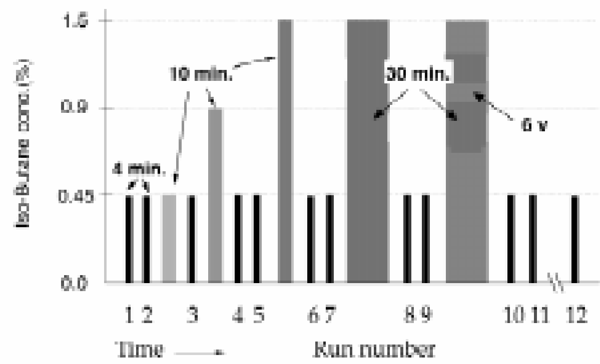

Fig. 15 - Test procedure for gas exposure

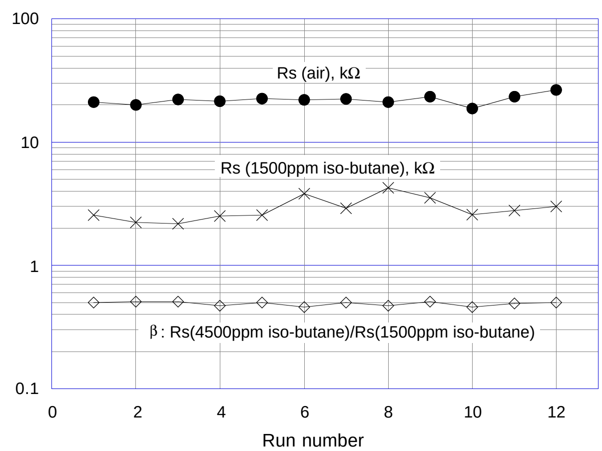

Fig. 16 - Effect of iso-butane exposure on Rs

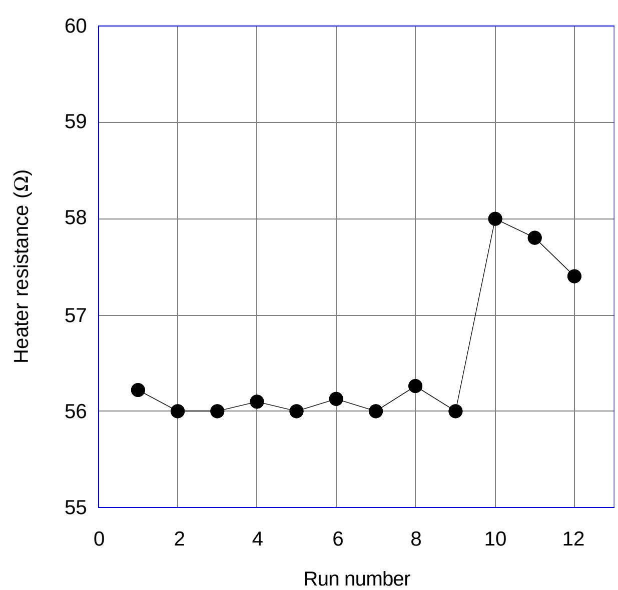

Fig. 17 - Effect of gas exposure on heater resistance

3-2 *Gas exposure test #2*

Figure 18 shows the effect on TGS2610 of a high concentration of ethanol vapor on sensor characteristics.

Sensors were energized and their resistance prior to ethanol exposure was measured. The sensors were then placed in a 10% concentration of ethanol for 20 hours. After this exposure, the sensor was energized in normal air for 1 hour prior to measuring sensor resistance. After an additional 1 day of energizing, the sensor resistance was measured again.

As this data would suggest, sensor characteristics remain largely unaffected after exposure to a high concentration of ethanol.

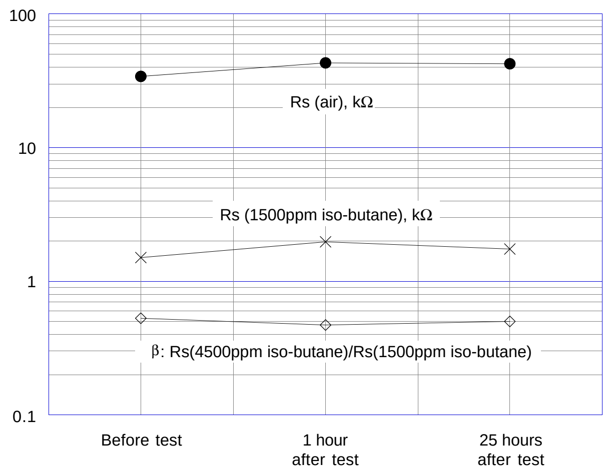

Fig. 18 - Effect of 10% ethanol exposure

3-3 *Corrosion test*

Figure 19 shows the effect on TGS2610 of corrosive gases specified in Item 43.15 of the UL 1484 standard.

Sensor resistance prior to corrosive gas exposure was measured. Unenergized sensors were then placed into an environment of 23°±2°C and 95%RH. In this environment, two separate tests were conducted: one in 0.1% H_2S, the other in a combination of 0.5% SO_2 and 1.0% CO_2, with each test exposure lasting 10 days. After this exposure, the sensor was re-energized in normal air prior to measuring sensor resistance after removal from corrosive gases.

As this data would suggest, sensor characteristics remain largely unaffected after exposure to corrosive gas concentrations specified by Sec. 43.15 of UL 1484.

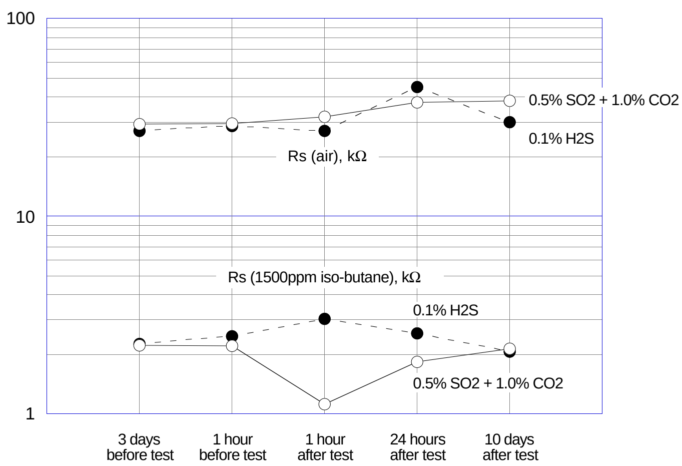

Fig. 19 - Corrosion test

3-4 *Ignition test*

TGS2610 has been successfully tested against the ignition test requirements of the UL1484 standard. The sensor did not initiate ignition of a propane concentration of 5.25% by volume.

3-5 *Effect of air flow*

Figure 20 shows how the sensor signal (VRL) is affected by air flow. The test procedure involves situating the sensor in an air stream of 3.1 meters per second, with the air flow vertical/horizontal to the flameproof stainless steel double gauze of the sensor's housing.

The decrease in sensor signal shown in Figure 20 resulted from the decrease in sensor element temperature caused by the air flow. As a result, direct air flow on the sensor should be avoided.

3-6 *Heater resistance durability*

Figure 21 illustrates the procedure for testing the effects of excess voltage applied to the heater. Heater resistance was measured while the heater was unpowered and at room temperature.

The results of this test are shown in Figure 22 which shows the change in resistance of the heater when various heater voltages (rather than the standard 5.0V) are applied in the absence of gases.

As this section demonstrates, the heater shows good durability against increased heater voltage. However, since excessive heater voltage will cause the sensor's heater resistance to drift upwards, excessive heater voltage should still be avoided.

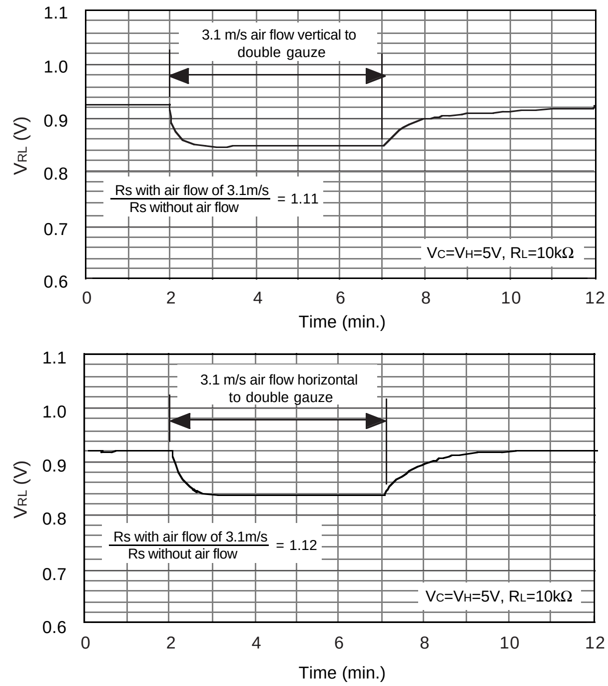

Fig. 20 - Effect of air flow

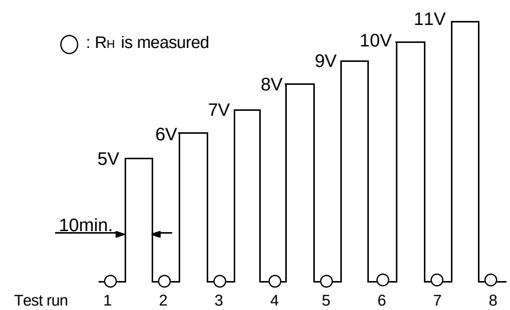

Fig. 21 - Test procedure for heater durability

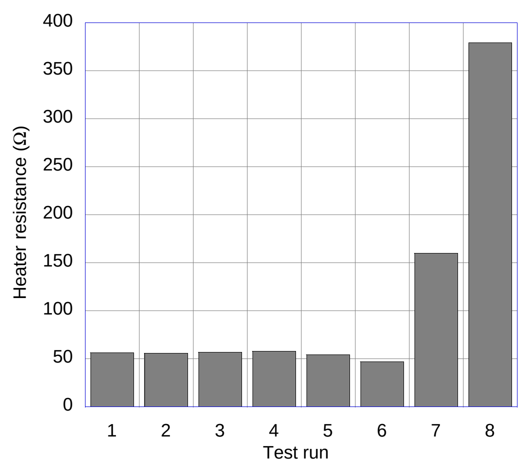

Fig. 22 - Short-term effect of VH on RH