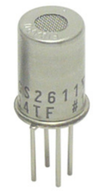
FIGARO

an ISO9001 company

Technical Information for Methane Gas Sensors

The Figaro 2600 series is a thick film metal oxide semiconductor, screen printed gas sensor which offers miniaturization and lower power consumption. The TGS2611 displays high selectivity and sensitivity to methane.



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.

TGS2611-E is a UL recognized component in accordance with the requirements of UL2075. *Please note that component recognition testing has confirmed long term stability in 60ppm of methane; other characteristics shown in this brochure have not been confirmed by UL as part of component recognition.*

1. Basic Information and Specifications

1-1 *Features*
- High selectivity to methane
- Low power consumption
- Small size
- Long life and low cost
- Uses simple electrical circuit

1-2 *Applications*
- Residential gas alarms
- Portable gas detectors
- Gas leak detectors for gas appliances

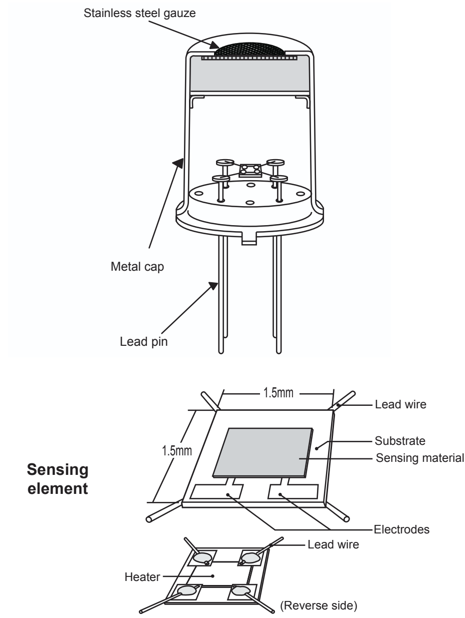


Fig. 1 - Sensor structure

1-3 *Structure*

Figure 1 shows the structure of TGS2611. 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). The TGS2611-E utilizes a proprietary filter material inside the cap for reducing the influence of interference gases.

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.

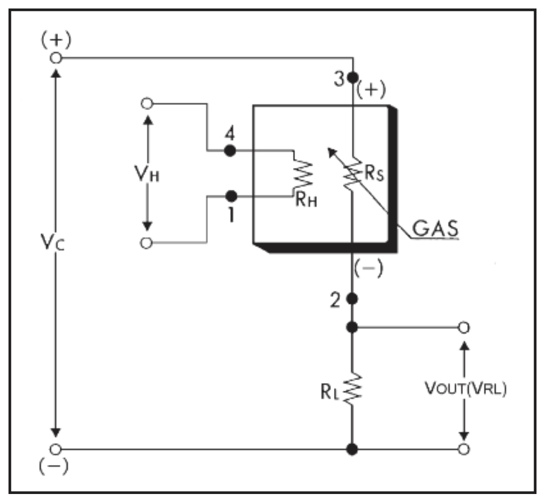


Fig. 2 - Basic measuring circuit

NOTE: In the case of V_H, there is no polarity, so pins 1 and 4 can be considered interchangeable. 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.

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

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	-40°C ~ +70°C
Typical detection range	1~25% LEL

1-6 *Specifications* NOTE 1

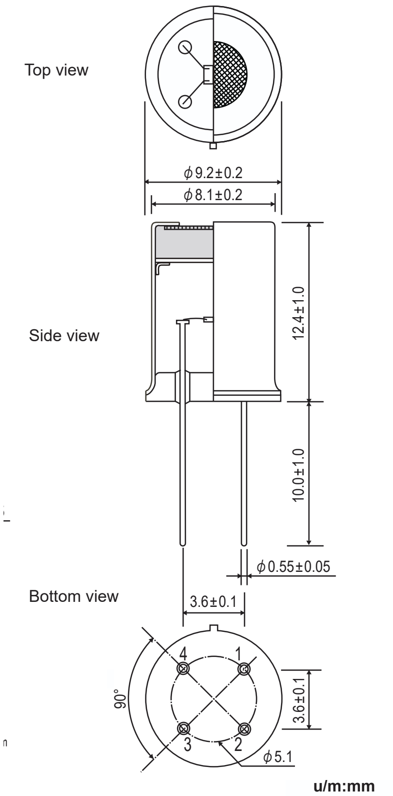
Item	Specification
Sensor resistance (5000ppm methane)	0.83kΩ ~ 8.3kΩ
Sensor resistance ratio (ß)	0.52 ~ 0.65
ß = Rs(9000ppm methane)/Rs(3000ppm methane)	
Heater current (R_H)	56 ± 5mA
Heater power consumption (P_H)	280m±25W

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: 4 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-1000cycles/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 TGS2611 to various gases. The Y-axis shows the ratio of the sensor resistance in various gases (Rs) to the sensor resistance in 5000ppm of methane (Ro).

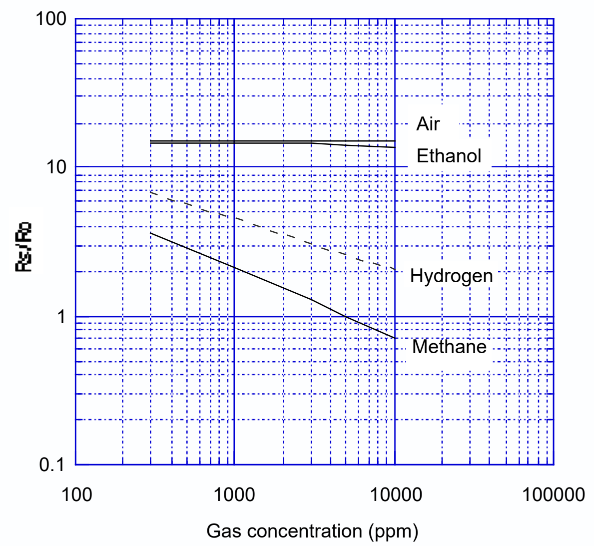


Fig. 4 - Sensitivity to various gases (Rs/Ro)

Using the basic measuring circuit illustrated in Fig. 2, and with a matched RL value equivalent to the Rs value in 5000ppm of methane will provide sensor output voltage (VRL) change as shown in Figure 5.

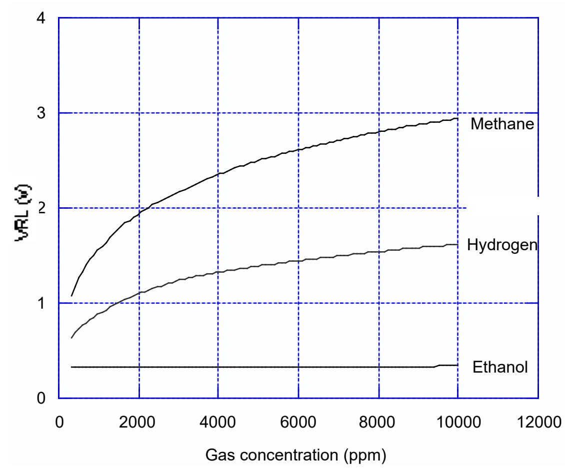


Fig. 5 - Sensitivity to various gases (VRL)

<u>NOTE</u>:
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'*).

2-2 *Temperature and humidity dependency*

Figure 6 shows the temperature and humidity dependency of TGS2611. The Y-axis shows the ratio of sensor resistance in 5000ppm of methane under various atmospheric conditions (Rs) to the sensor resistance in 5000ppm of methane at 20˚C/65%RH (Ro).

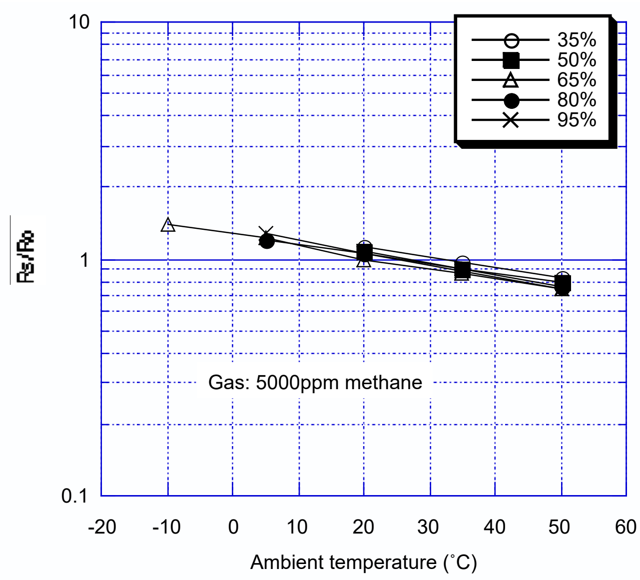


Fig. 6 - Temperature and humidity dependency (Rs/Ro)

RH / (˚C)	35%RH	50%RH	65%RH	80%RH	95%RH
-10			1.40		
5			1.24	1.20	1.27
20	1.13	1.09	1.00	1.05	1.06
35	0.96	0.90	0.87	0.90	0.88
50	0.84	0.80	0.74	0.76	0.74

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

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 TGS2611 to methane 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'*).

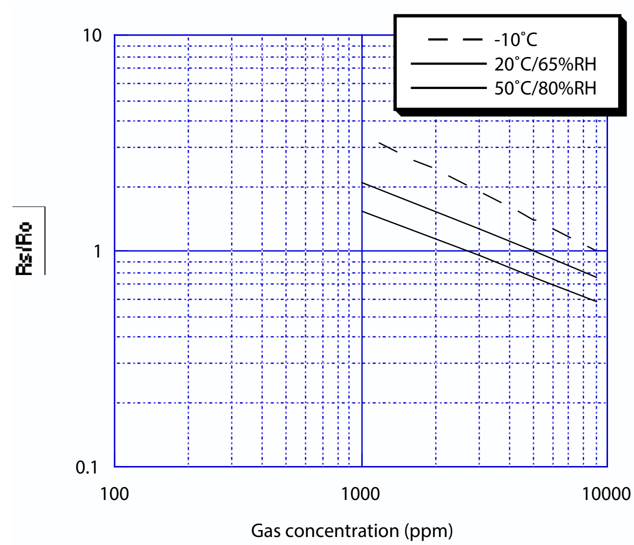


Fig. 7 - Resistance change ratio
under various ambient conditions

2-3 *Heater voltage dependency*

Figure 8 shows the change in the sensor resistance ratio according to variations in 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.

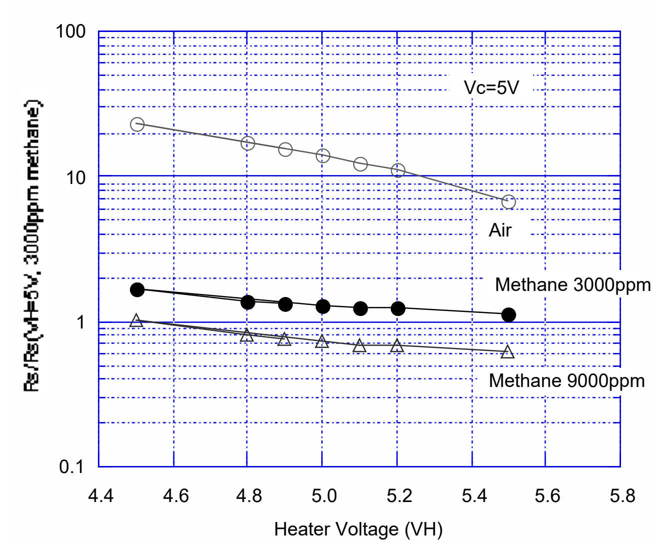


Fig. 8 - Heater voltage dependency (Vc=5.0)

2-4 *Gas response*

Figure 9 shows the change pattern of sensor resist-ance (Rs) for TGS2611 when the sensor is inserted into and later removed from 5000ppm of methane.

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.

Figure 10 demonstrates the sensor's repeatability by showing multiple exposures to a 5000ppm concentration of methane. Unlike the test done for Fig. 9, 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.

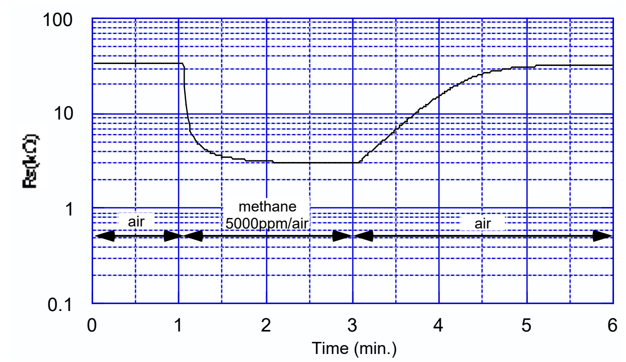


Fig. 9 - Gas response to methane

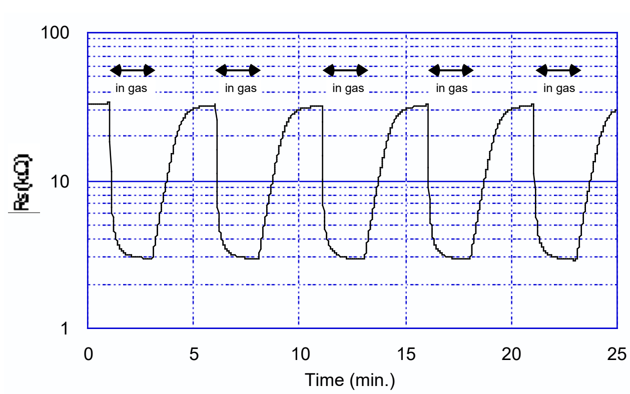


Fig. 10 - Repeatability

2-5 *Initial action*

Figure 11 shows the initial action of the sensor resistance (Rs) for a sensor which is stored unenergiz-ed in normal air for 90 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.

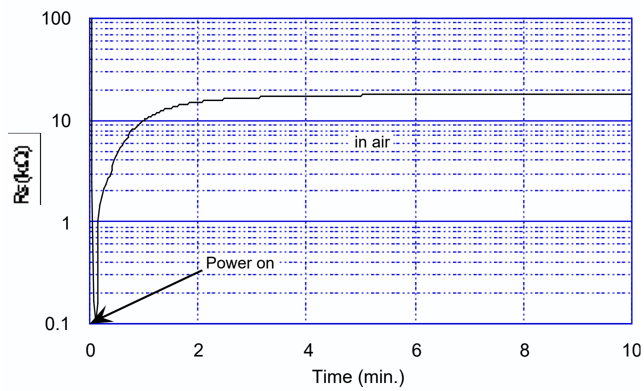


Fig. 11 - Initial action

2-6 *Long-term characteristics*

Figure 12 shows long-term stability of TGS2611 as measured for more than 1900 days. The sensor is usually energized in normal air. Measurement for confirming sensor characteristics is conducted under standard test conditions. The initial value of Rs was measured after preheating for at least three days in normal air at the rated voltage. The Y-axis represents the sensor resistance in air, 5000ppm of methane, 3000ppm of hydrogen, and 3000ppm of ethanol.

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

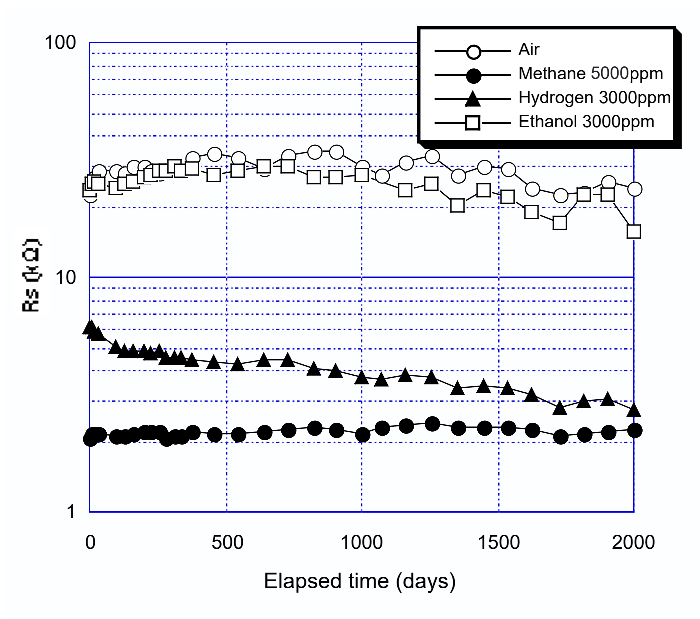


Fig. 12 - Long-term stability (continuous energizing)

3. Reliability

3-1 *Ignition test (*)*

TGS2611 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.

3-2 *HMDS test*

Figure 13 shows the effect on TGS2611 of silicone vapor. Sensor resistance prior to HMDS (Hexamethyl disiloxane) gas exposure was measured (Ro). Energized sensors were placed into an environment of 20˚C/50%RH. In this environment, the sensors were exposed to HMDS at 10 ppm for 40 minutes, 30 ppm for 40 minutes and 100 ppm for 40 minutes (test
conditions specified in Item 5.3.13 of the ES (*European standard*) EN50194: 10ppm for 40 min.). After exposure, the sensor was returned to normal air. Sensor resistance (Rs) in both air and 5000ppm of methane were measured at 1 hour, 1 day, and 1 week after being removed from HMDS.

As this data would suggest, sensor characteristics remain largely unaffected by exposure to HMDS gas concentrations.

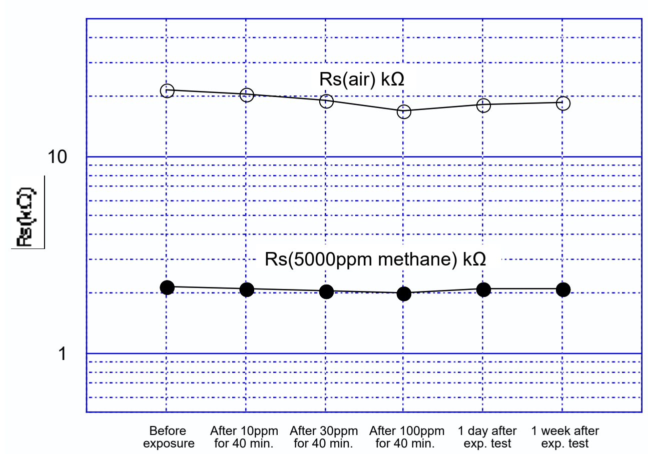


Fig. 13 - Durability to HMDS exposure

(*) The UL 1484 referenced tests have not been reviewed or accepted by Underwriters Laboratory as part of the component recognition.

4 Cautions

4-1 *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, SO_x, 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) Excessive exposure to alcohol
IF TGS2611-E00 is exposed to high concentrations of alcohol (such as 10,000ppm or more) for a long period of time, the filter may become saturated. In this case, the sensor would show a lower resistance in alcohol than that indicated in Figure 4.

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

10) Lighter gas exposure test
Consumers often check if detectors are actually sensing gas by exposing them to lighter gas (main component is iso-butane). Because the filter will block iso-butane from reaching the sensing element, this test **cannot** be used with TGS2611-E00.

4-2 *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) 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.

NOTE: To achieve the optimal level of accuracy in gas detectors, each TGS2611 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).

For the convenience of users, TGS2611 is classified into 24 groups according to the each sensor's Rs in methane. ID numbers marked on the sensor's body indicate the sensor's grouping. Individual sensor calibration can be eliminated by matching the sensor with the recommended RL for each sensor ID. However, because group calibration is used instead of individual calibration, an average of 10% less accuracy would result for detectors using group calibration. Please refer to "*Application Notes for TGS2611-E00*" for more information.

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