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Technical Information

Electrochemical CO Gas Sensor

NE4-CO

For Industrial Applications

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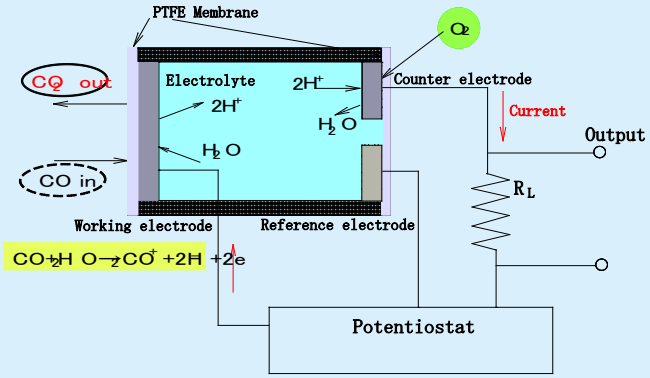
General

Nemoto NE4 series sensors were developed for industrial applications, and NE4-CO is a standard type electrochemical CO gas sensor. Shape, pin positions and basic features are compatible with others, however the stability, repeatability, durability and reliability are superior to others, but the price is competitive with the others. Features and applications are as follows.

1. Detection principle



Electrochemical sensor consists of working electrode on which oxidization takes place, counter electrode on which reduction takes place, and reference electrode which can monitor and keep the voltage at constant. Structure of electrochemical sensor is shown in right figure, CO gas diffuses through membrane into working electrode, and CO is oxidized to CO2 at working electrode. Generated proton at this reaction proceeds to counter electrode, and reacts with dissolved oxygen in electrolyte to water. Total reaction is in the above. CO gas concentration is proportional to the current that is generated by serial reaction.

2. Features

・Quick response and large sensitivity
・Excellent selectivity
・Good linearity and stability
・High reliability and long lifetime
・Excellent durability against high temperature and humidity

3. Detected gas

Carbon monoxide

4. Application

・CO gas densitometer for industrial application
・CO gas alarm for industrial equipment
・Handheld type CO gas leakage checker
・Environmental monitoring equipment
・ Fire alarm

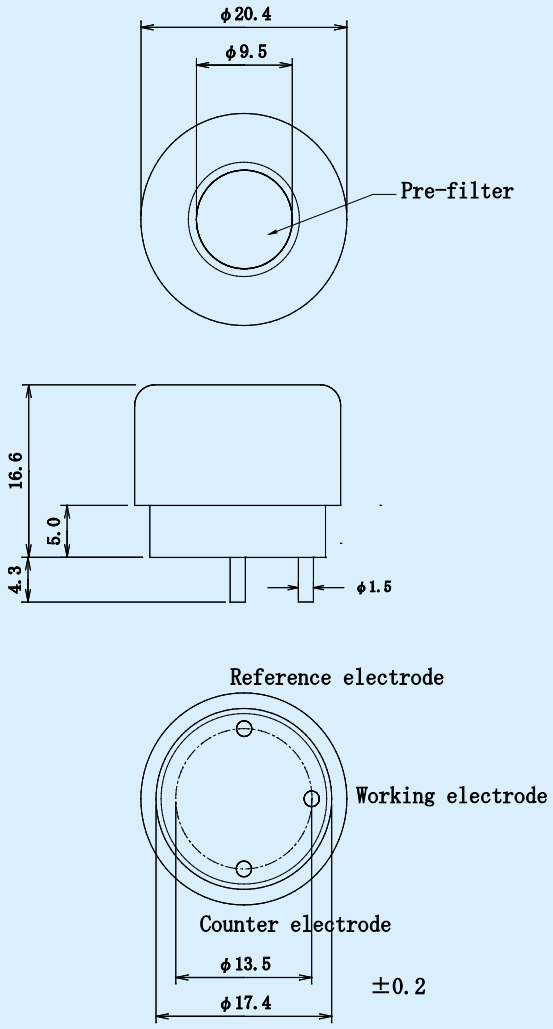
5. Ratings

1) Ambient temperature and humidity in operation	Temperature : -20 - +50 degree C Humidity : 15 – 90%RH
2) Recommended ambient temperature and humidity in storage	Temperature : 0 – 20 degree C Humidity : 15 – 90%RH
3) Operating pressure range	0.9 – 1.1 atm
4) Detection range	0 - 1,000ppm
5) Maximum overload	2,000ppm
6) Recommended load resistor	10 ohm

6. Specifications

1) Output signal	70 +/- 15nA/ppm.CO at 20 degree C
2) Zero offset in clean air	< +/- 5ppm equivalent
3) Response time (T90)	Less than 30sec.
4) Repeatability in the same day	Less than 2% of signal
5) Annual zero offset drift at 20 degree C	Less than 5ppm of CO
6) Zero offset temperature dependence (-20 ~ +50 degree C)	Less than 10ppm of CO
7) Sensitivity reduction in long term	Less than 5% signal loss/year
8) Lifetime warranty	36 months
9) Recommended storage time	Less than 6 months

7. Dimensions and appearance



Case Material	PPO
Cap Color	Light grayish Green
Weight	5 g（approx.）

Fig.1：Appearance and dimensions of NE4-CO

8. Electrical properties

9-1. Typical gas sensitivity

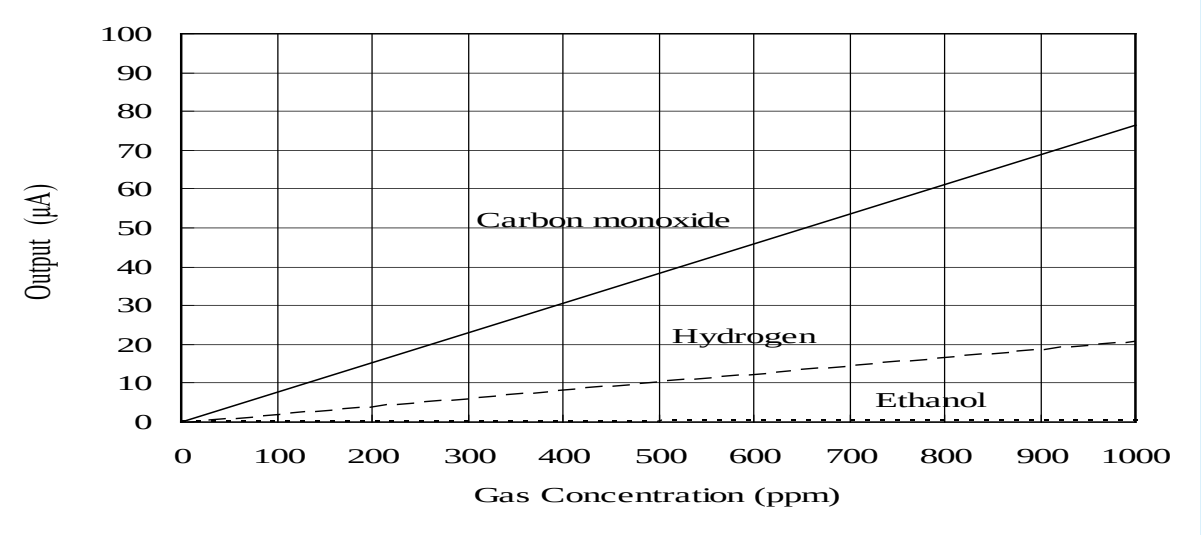


Fig.2 : Gas Sensitivity of NE4-CO

9-2. Cross Sensitivity

Table 1 : Cross Sensitivity of NE4-CO

Detected gases	Relative sensitivity (Sensitivity to CO is 100.)
Carbon-monoxide	100
Hydrogen	40
Methane	0
Iso-butane	0
Carbon-dioxide	0
Sulfur-dioxide	0
Hydrogen Sulfide	0
Nitric Oxide	Less than 15
Nitrogen Dioxide	0
Ammonia	0
Ethyl Acetate	0
Heptane	0
Ethanol	Less than 10*
Chlorine	0
Ethylene	Less than 80

Exposure time : * 30 minutes

9-3. Temperature dependence

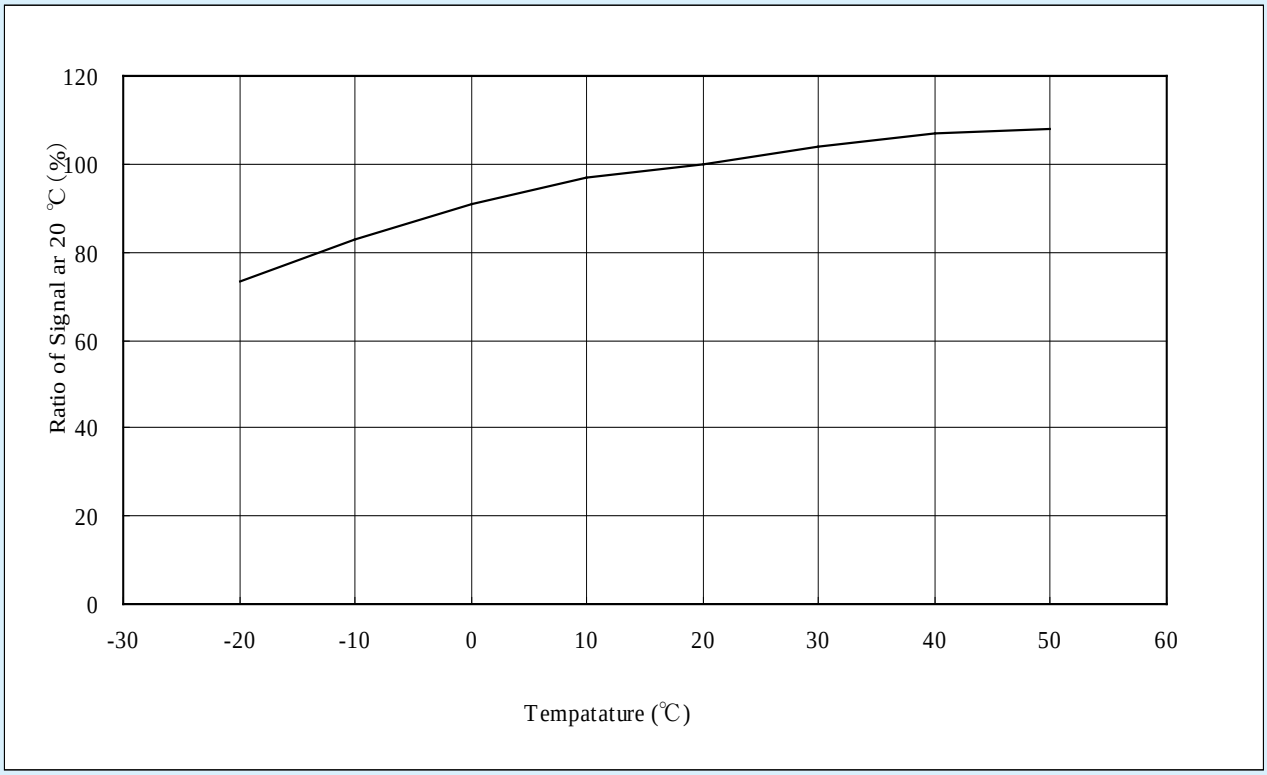


Fig.3 : Typical temperature coefficient of NE4-CO
(100 at 20 degree C)

9-4. Response and recovery characteristics

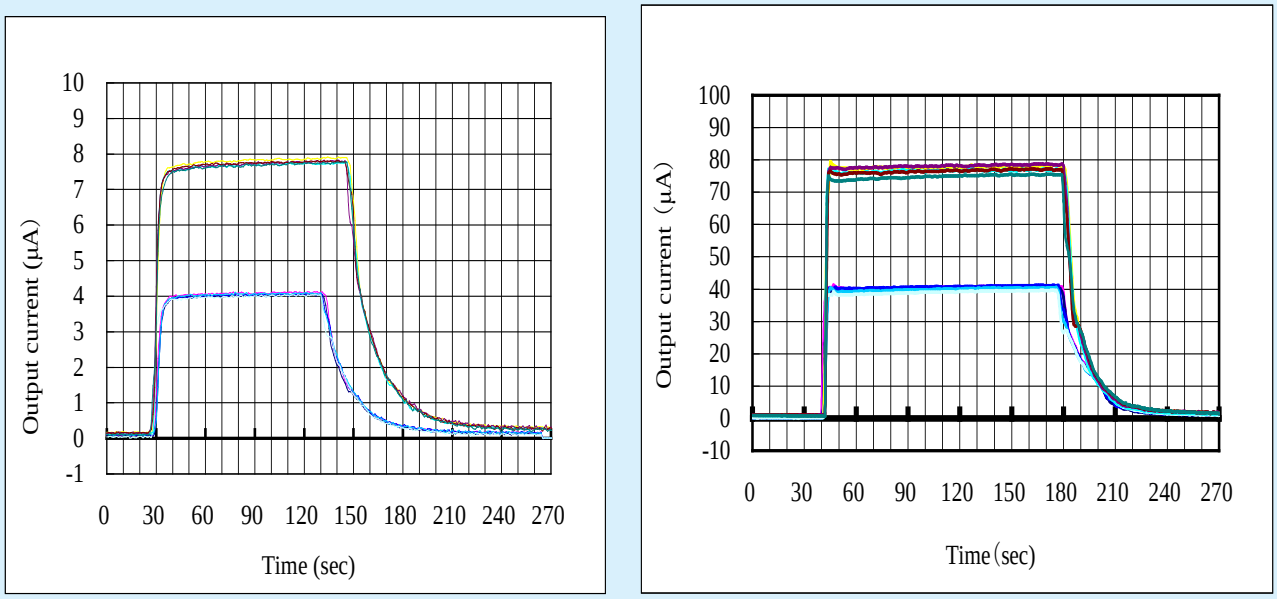


Fig.4 : Response and recovery characteristics
(at 20 degree C)

9-5. Linearity to high concentration of CO

NE4-CO can detect high concentration of CO with excellent linearity.

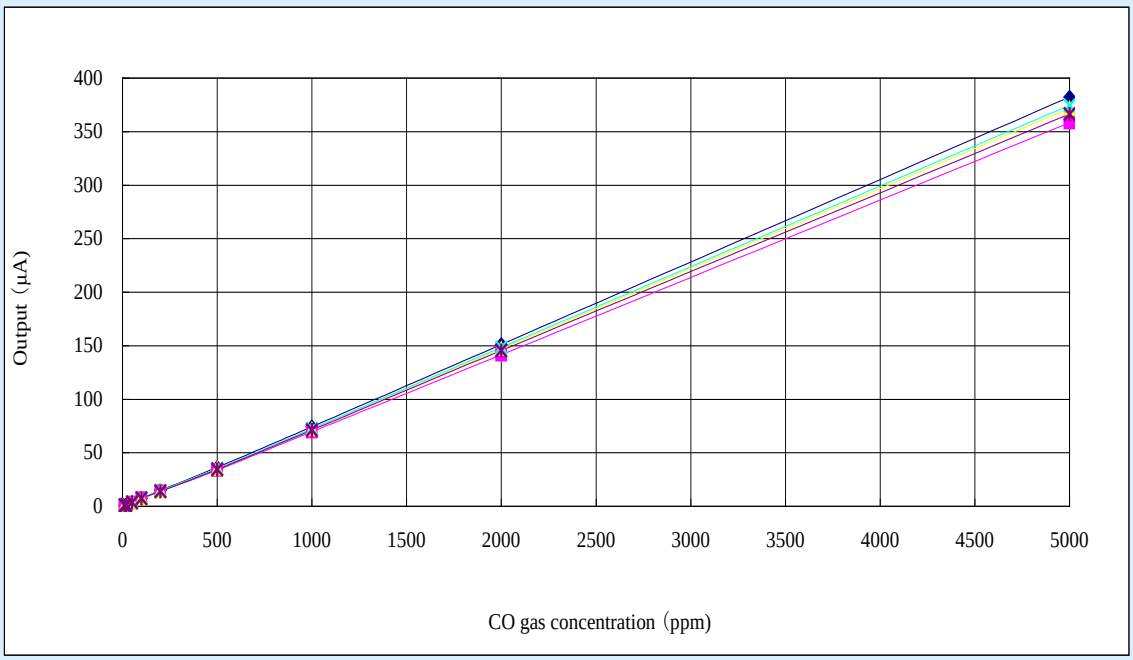


Fig.5 : Linearity of NE4-CO

9-6. Long term stability

It is quite stable in normal circumstance for over 2 years.

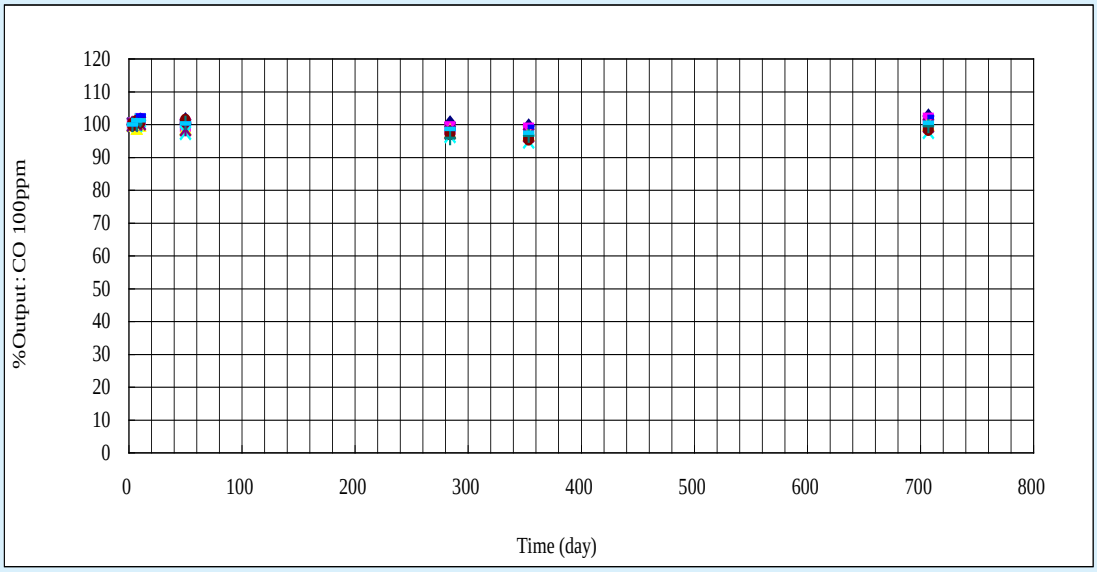


Fig.6 : Long term stability in normal circumstance

9. Durability

NE4-CO is much durable in strict environment such as high temperature and high humidity, or in high temperature with dry. Features are as follows.

10-1. High temperature durability

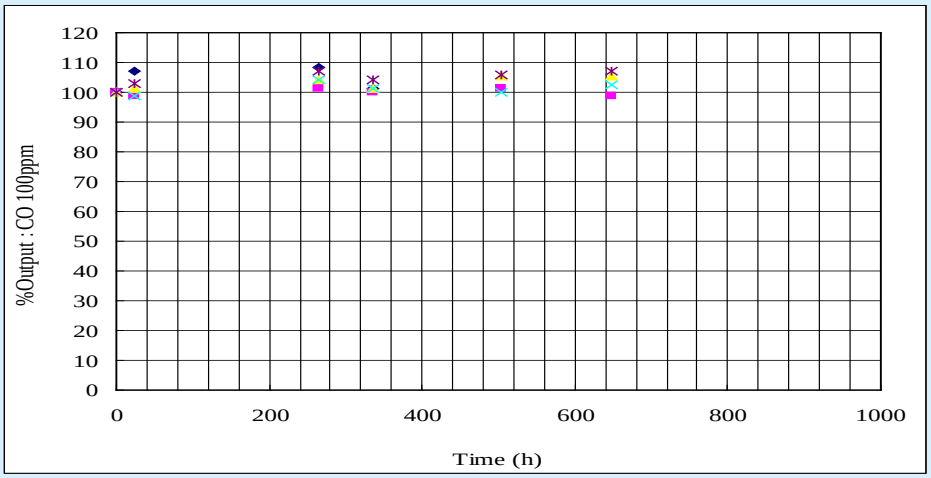


Fig.7 : Durability in high temperature (50 degree C) and high humidity (90%RH)

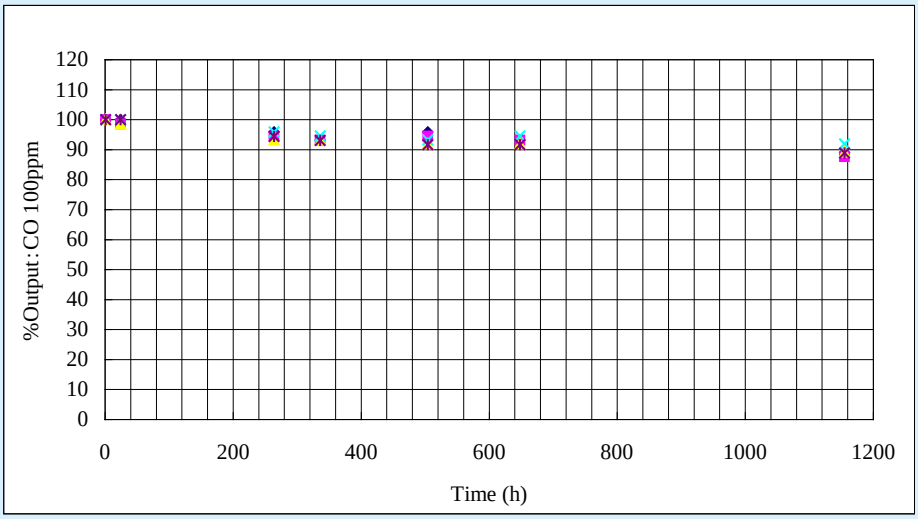


Fig.8 : Durability in high temperature (50 degree C) with dry circumstance.

10-2. Low temperature durability

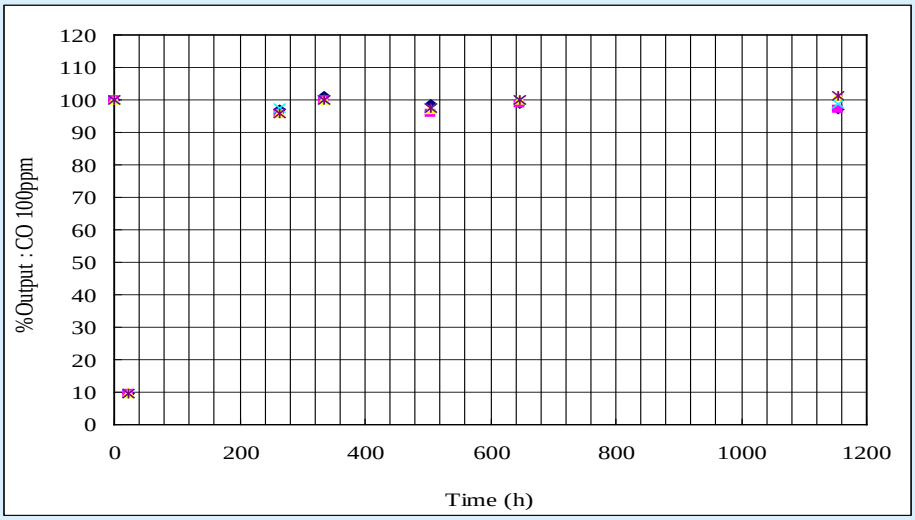


Fig.9 : Durability in low temperature (-20 degree C)

10-3. Exposure test in high concentration of CO

Test conditions CO gas concentration : 3,000ppm
Exposure time : 20hrs. continuous
Temperature and humidity : 25+/-1 degree C, 50+/-10%RH

Table 2. Exposure test in High concentration of CO gas

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	
1	0.06	7.17	-0.02	7.19	100.3
2	0.06	7.27	-0.01	7.30	100.4
3	0.07	7.36	-0.01	7.27	98.8
4	0.09	7.71	0.01	7.80	101.2
5	019	7.92	0.02	7.81	98.6

10-4. Thermal shock test

Test conditions

Sensor is stored in -20 degree C for 30min. and in +50 degree C for 30 min. respectively, and this cycle were repeated for 10 times.

Table 3. Thermal shock test

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	
1	-0.25	7.82	-0.26	7.80	99.7
2	-0.29	7.34	0.30	7.44	101.4
3	-0.21	7.22	-0.22	7.28	100.8
4	-0.30	7.10	0.21	7.16	100.8
5	-0.15	7.33	0.16	7.42	101.2

10-5. Drop test

Test conditions

Sensor is dropped to concrete floor from the height of 1m with free fall for 5 times.

Table 4. Drop test

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	
1	0.18	7.37	0.18	7.37	100.0
2	0.22	7.63	0.26	7.59	99.5
3	0.19	7.45	0.24	7.40	99.4
4	0.21	7.81	0.12	7.90	101.2
5	0.22	7.68	0.31	7.59	98.8

10-6. Exposure in noise gas

A. Exposure in SO2 gas

Test conditions

Sensor is exposed in 500ppm of sulfur dioxide for 30min. at normal temperature and humidity.

Table 5. Exposure in SO2

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	
1	0.18	8.02	0.19	8.06	100.5
2	0.12	7.75	0.17	7.71	99.4
3	-0.06	7.50	0.03	7.58	101.1
4	0.06	7.90	0.13	7.84	99.3
5	0.22	7.39	0.31	7.36	99.6

B. Exposure in ethanol gas

Test conditions

Sensor is exposed in 2000ppm of ethanol for 30min. at normal temperature and humidity.

Table 6. Exposure in ethanol

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	
1	0.16	8.10	0.25	8.02	99.0
2	0.14	7.76	0.30	7.80	100.5
3	0.02	7.51	0.29	7.46	99.3
4	0.12	7.89	0.30	8.04	101.9
5	0.29	7.35	0.31	7.53	102.4

C. Exposure in NO2 gas

Test conditions

Sensor is exposed in 800ppm of nitrogen dioxide for 30min. at normal temperature and humidity.

Table 7. Exposure in NO2

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	
1	0.26	8.05	0.14	7.90	98.1
2	0.24	7.95	0.15	7.85	98.7
3	0.25	7.98	0.16	7.86	98.4
4	0.22	7.83	0.14	7.78	99.4
5	0.20	7.89	0.14	7.87	99.7

D. Exposure in acetone gas

Test conditions

Sensor is exposed in 1500ppm of acetone for 1 hour at normal temperature and humidity.

Table 8. Exposure in acetone

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	
1	0.09	8.08	0.26	8.01	99.0
2	0.06	7.95	0.28	7.90	99.5
3	0.07	7.96	0.22	7.90	99.2
4	0.06	7.81	0.17	7.76	99.4
5	0.04	7.95	0.18	7.88	99.1

E. Exposure in HMDS gas

Test conditions

Sensor is exposed in 100ppm of HMD (Hexa-methyl di-siloxane) for 1 hour at normal temperature and humidity.

Table 9. Exposure in HMDS

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	Zero offset in air at 20 degree C	Sensitivity to 100ppm of CO	
1	0.32	8.13	0.33	8.07	99.3
2	0.31	8.07	0.34	7.72	95.6
3	0.29	8.08	0.32	7.92	98.0
4	0.26	7.92	0.34	7.81	98.6
5	0.25	8.02	0.34	7.83	97.6

10. Recommended circuit diagram

Recommended circuit diagram for evaluation of NE4-CO is shown in figure 10. In this circuit diagram, OP97 as operational amplifier is employed, however the other low price one is to be applicable for actual use. And, thermistor is employed, resistance value of 10Kohm at 25 degree C and around 3500 as B constant is recommended. Ishizuka thermistor is not pointed, and another one is also available.

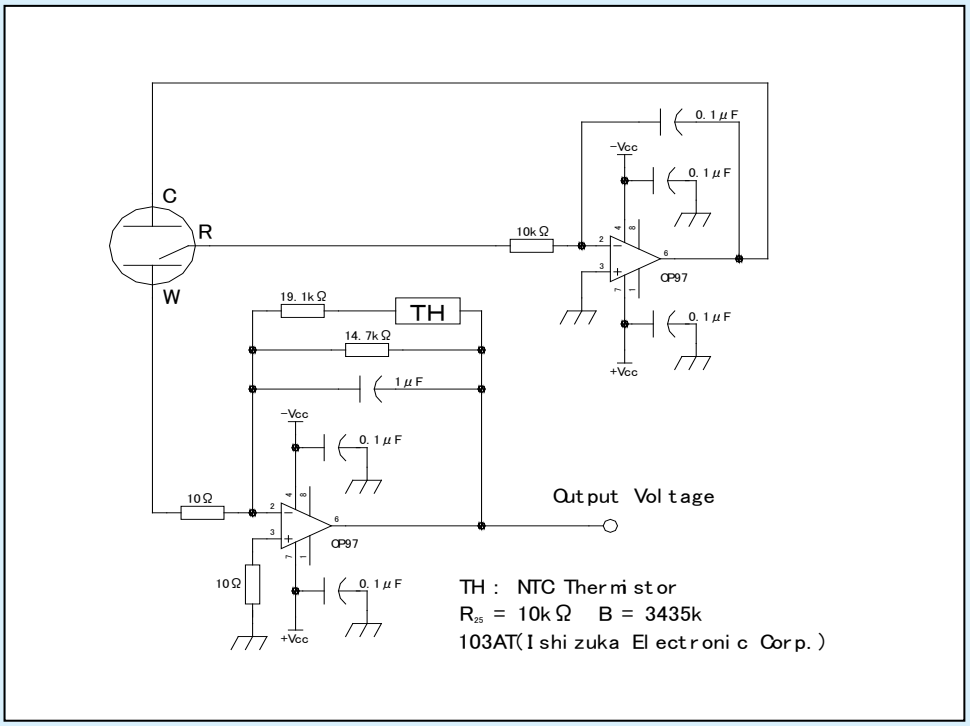


Fig. 10 : Measuring circuit diagram for evaluation

12. Notice on handling

12-1. Seasonal variation of sensitivity

Highly hygroscopic electrolyte is normally employed for electrochemical sensor, and then the sensitivity varies according to change of temperature and humidity, i.e. sensitivity is little lower in low humidity than in high humidity. Since it is because of amount of electrolyte, this seasonal variation of sensitivity should be taken into account in case that precise measurement is necessary. However, this variation is reversible phenomenon.

12-2. Design of gas alarm or gas densitometer

a. Calibration of gas alarm or gas densitometer is to be carried out in clean air after the output was stabilized.
b. Gas sensitivity reduction ratio of 5% per year is to be taken into account at designing of gas alarm as recommendation. In case that precise detection is required, periodical calibration once or twice a year is recommended.

c. In case that water drop or oil is on the pre-filter, accurate measurement may not be available because of low diffusion of detected gas to sensor. If such accident may be conceived,

design of prevention from such one is to be considered.

d. Warranty time is 2 years in case of being used in normal circumstance.

12-3. Storage of sensor

It is recommended that electrochemical sensor should be stored in normal temperature and humidity, possibly 0-20 degree C, of clean air.

Recommended storage time after delivery is less than 6 months. If the storage time is extended, the warranty term is to be shortened. It is because the lifetime of electrochemical sensor is not dependent on being electrified or not like semi-conductive type or catalytic type, and then this matter is to be correctly comprehensive in order to keep quality.

12-4. General notice

- Use only within specified conditions.
- Sensor characteristics must be measured in clean air.
- Electrode pins must be correctly connected. Wrong connection does not allow correct functions.
- Do not apply voltage directly to electrode pins.
- Do not bend pins.
- Do not put excess vibration or shocks.
- If sensor housing is damaged or scratched, do not use.
- Do not blow organic solvents, paints, chemical agents, oils, or high concentration gases directly onto sensors.
- Do not solder pins of sensor directly. Use exclusive sockets.
- Do not disassemble or change any parts.
- In case that sensor is stored by detachment from circuit board, it is recommended that working electrode pin should be short-circuited with reference electrode pin in order to shorten the initial stabilization time.
- If sensor is used under irregular atmosphere, contact us.

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