C9E-0030

RIKEN KEIKI

CONDENSED CATALOG

PART-I

Portable Gas Detector

Gas Detector for Combustible Gases/Oxygen/Toxic Gases

RIKEN KEIKI Co.,Ltd.

"Creating safe working environments for workers"

RIKEN KEIKI was established in 1939 as part of RIKEN conglomerate (currently called RIKEN, a national R&D corporation). For nearly 8 decades since its birth, it has dedicated itself in developing unique technology for the industry.

In our living environment, environmental pollution is threatening our lives and precious assets.

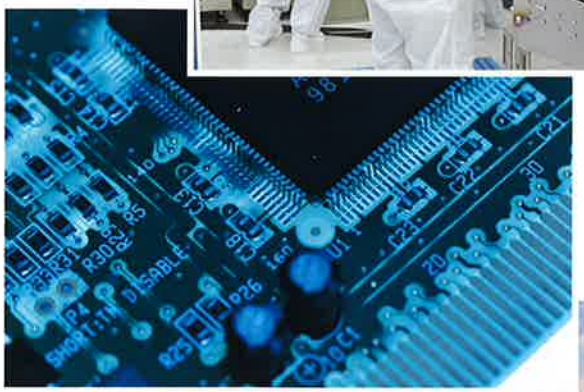
Even before there were any warnings of an environmental crisis, we have contributed to society with our industrial pollution/disaster prevention instruments.

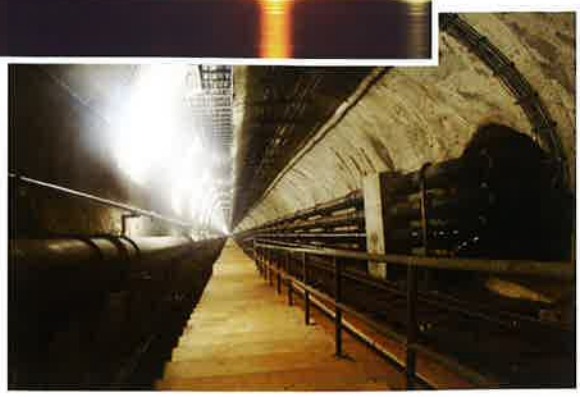
At present, we produce from large-scale gas detecting alarm systems to small-sized personal gas monitors for safety protection in many industries.

In addition, our gas detector are widely used in the semiconductor and space development industries.

We also have a large share of gas measuring instruments in the fields of pollution prevention and health care.

With growing needs for disaster prevention and environmental preservation, we are determined to continue developing reliable technologies utilizing our scientific knowledge and skills under the eternal goal of safety "Creating safe working environments for workers."





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Regarding Portable Gas Detector

A portable type gas detector is, as the name suggests, handheld type a worker can carry or attach to the body. It is possible to detect and measure toxic gas around a moving worker and/or in specific places which may be dangerous, different from fixed gas detect. It can discover the leakage at the early stage, of such as combustible gases which may stay in the air and might cause the explosion and of such as toxic gases that cause the adverse effect to the human body, and can also manage the concentration of indispensable oxygen for us. As the result, all the accidents that originate in the gases can be prevented.

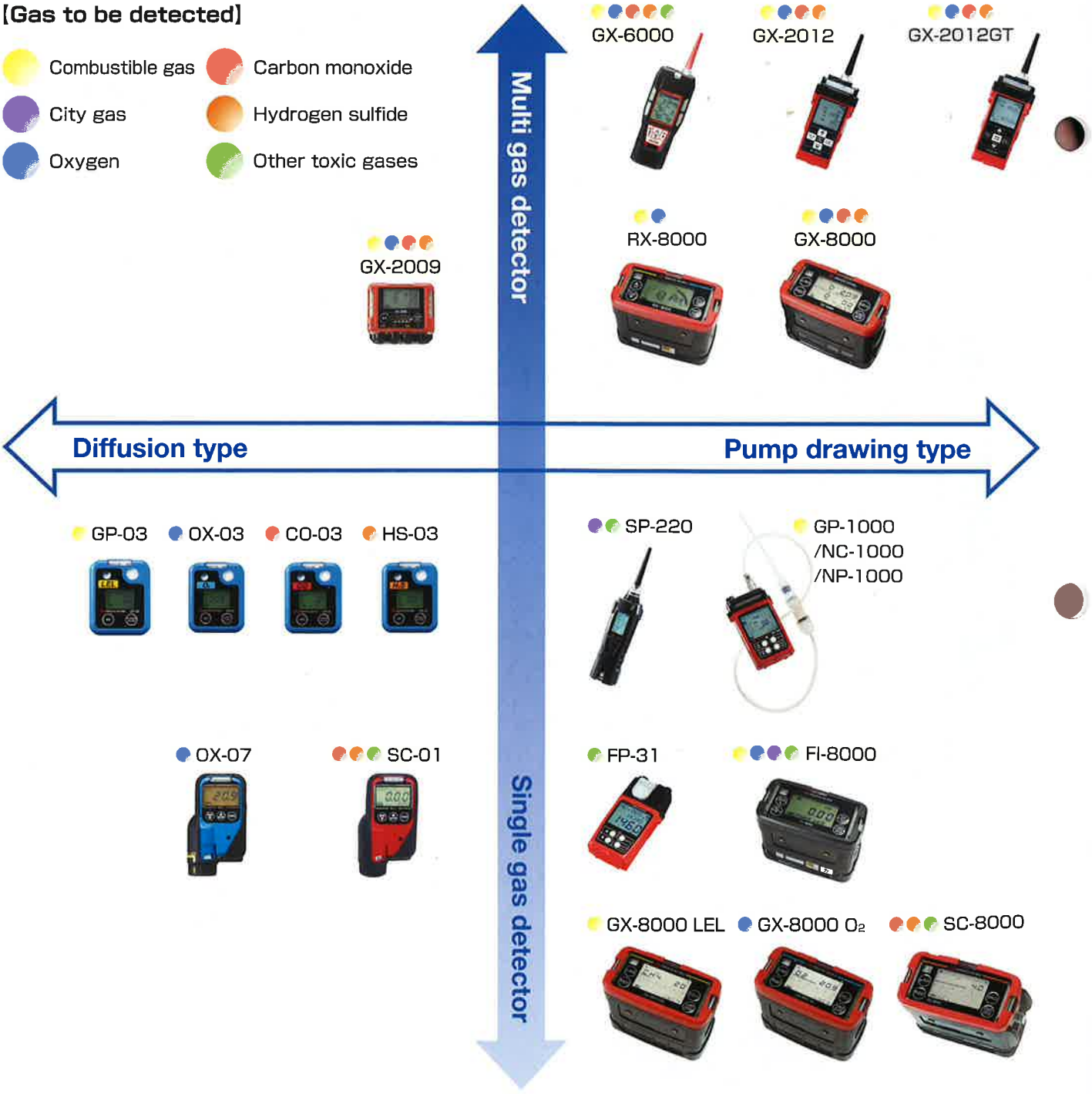
There are two gas sampling methods for the detector to adjust to miscellaneous environments. One is the pump drawing type. The usages of the sampling method are wide-ranging, such as finding a leaking position and/or inspecting the danger of potential gases prior to the working in a manhole and/or a tank utilizing the drawing function of the pump built in the main body of the device. The other is a diffusion type. The type is mainly used to monitor the peripheral safety of a worker in real time as the instrument is small and light due to the pump being not built in.

'Multi gas detector' which detects above-mentioned two or more gases such as the dangerous gas, oxygen etc. and displays their concentrations at the same time has been the main current stream of the detector, and RIKEN KEIKI has also lined up a wide series of detector.

Type of Portable Gas Detector

[Gas to be detected]

- Combustible gas
- Carbon monoxide
- City gas
- Hydrogen sulfide
- Oxygen
- Other toxic gases



Necessity of Maintenance

The implementation of regular maintenance is extremely important to maintain the performance and to improve reliability on disaster prevention and security in using the gas detector. Accurate detection cannot be implemented if the device is continued to use without maintenance.

There are maintenances that are the daily and monthly maintenances to be implemented by the workers and the regular maintenance to be implemented by the service engineer of RIKEN KEIKI. Daily maintenance is a visual check to be implemented by the worker before the beginning of the work. The monthly maintenance is the maintenance of the alarm circuit (alarm test) to be implemented by the worker once a month. The regular maintenance are checks such as the sensitivity calibration etc. to maintain the performance as the security equipment to be implemented once every six months.

In Japan, regarding the special high pressure gas, especially, is obligated in Exemplified Standards concerning Safety Regulations for General High Pressure Gas, saying that 'Calibration of the reading of gas leakage detection alarm equipment for special high pressure gas shall be carried out at least once every six months.'

With correct execution of maintenance, the performance and the function of the devices can be maintained to be excellent and the safety without the gas disaster can be secured, for a long term.

Enhanced Support Network

RIKEN KEIKI is working on the speed up of the emergency response and the regular maintenance.
RIKEN KEIKI has prepared the thorough system for after-sales service with technological members who have expertise and certain technical skill.

RIKEN KEIKI is aiming at the enhancement of the service network. RIKEN KEIKI as the manufacturer of the industrial disaster prevention devices always responds to the consultation and after-sales service with the responsibility concerning the product by allocating service engineers with expertise.

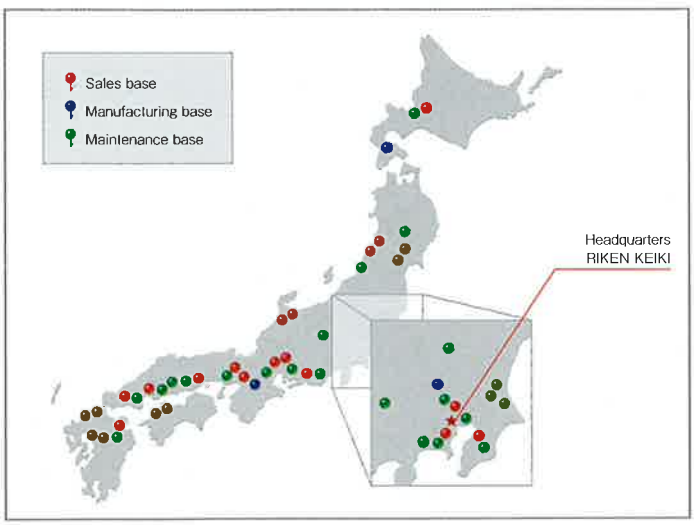
《International Bases》

International bases

North America	United States
South America	Brazil, Argentina, Peru, Chile, Uruguay
Asia-Pacific	China, South Korea, Taiwan, Singapore, Malaysia, Indonesia, Thailand, India, Vietnam, Philippines, Australia
Europe	Germany, Greece, Norway, Turkey, United Kingdom
The Middle East	United Arab Emirates, Israel
Africa	South Africa
Russia	Russian Federation

《Japanese Bases》

	Japanese sales bases	Japanese service bases
Hokkaido area	Sapporo	Sapporo
Tohoku area	Sendai, Tsuruoka	Iwate, Sendai, Tsuruoka
Kanto and Shinetsu area	Mito, Saitama, Chiba, Kanagawa	Tochigi, Mito, Kashima, Saitama, Chiba, Tokyo, Yokohama, Atsugi, Niigata, Matsumoto, Kofu
Tokai, Hokuriku and Kinki area	Hamamatsu, Nagoya, Yokkaichi, Kanazawa, Osaka, Kobe	Hamamatsu, Nagoya, Yokkaichi-higashi, Yokkaichi, Toyama, Keiji, Amagasaki, Himeji
Chugoku and Shikoku area	Mizushima, Shikoku, Hiroshima, Tokuyama	Mizushima, Shikoku, Higashihiroshima, Hiroshima, Tokuyama
Kyushu and Okinawa area	Fukuoka, Kumamoto, Oita	Tosu, Kumamoto, Oita



Multi Gas Detector

From the prevention of explosion accident to the voluntary management of chemical substances

Portable monitor for 6 gases

GX-6000

Explosion-proof ATEX, TIIS Explosion-proof authorized.
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

Drawing Pump drawing type

Features

- Up to 6 gases can be detected and displayed simultaneously.
- VOC can be detected by adoption of the PID sensor.
- Multi languages can be displayed (Japanese/English and others).
- Measurement in a dark place is safely done with the LED light.
- Equipped with panic alarm & man down alarm function.
- Intrinsic safety (Explosion-proof class: Exia II CT4X).

Specification

Model	GX-6000
Detection method	Pump drawing type Drawing flow rate: 0.45 L/min or more (open flow rate)
Gas to be detected	Refer to the following "List of gas to be detected".
Detection principle	
Detection range	
Alarm buzzer sound pressure	95 dB(A) or higher (30 cm) (with the protection cover mounted)
Display	LCD digital (full dot display) Display language: Japanese/English etc.
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)
Power supply	Lithium-ion battery unit or dry battery unit <3 AA alkaline battery>
Continuous operating time	Lithium-ion battery unit: approx. 14 hours (fully charged, 25°C, without alarm nor illumination) Dry battery unit: approx. 8 hours (new dry battery, 25°C, without alarm nor illumination)
External dimensions	approx. 70(W) × 201(H) × 54(D) mm (projection portions excluded)
Weight	approx. 500 g (lithium-ion battery unit is used) approx. 450 g (dry battery unit is used)
Protection level	IP67 equivalent

List of Gas to be Detected※1

Number mountable	No.	Gas to be detected	Detection principle	Detection range	1 digit
0 - 4 sensor (selectable)	1	Combustible gas (HC/CH_4)	New ceramic	0~100%LEL	1%LEL
	2	Oxygen (O_2)	Galvanic cell	0~40.0vol%	0.1vol%
	3	Hydrogen sulfide (H_2S)	Electrochemical	0~100.0ppm	0.5ppm
	4	Carbon monoxide (CO)		0~500ppm	1ppm
0 - 2 sensor (selectable)	5	Volatile organic compound (VOC)	PID	0~50000ppb	1ppb (~5000) ⇒10ppb (5000~)
	6	Volatile organic compound (VOC)		0~6000ppm	0.1ppm (~600.0) ⇒1ppm (600~)
	7	Sulfur dioxide (SO_2)	Electrochemical	0~100.00ppm	0.05ppm
	8	Nitrogen dioxide (NO_2)		0~20.00ppm	0.05ppm
	9	Hydrogen cyanide (HCN)		0~15.0ppm	0.1ppm
	10	Ammonia (NH_3)		0~400.0ppm	0.5ppm
	11	Chlorine (CL_2)		0~10.00ppm	0.05ppm
	12	Combustible gas (HC)	Non-dispersive infrared	0~100%LEL/0~30.0vol%※2	1%LEL/0.5vol%
	13	Carbon dioxide (CO_2)		0~10.00vol%	0.02vol%
	14	Combustible gas (CH_4)		0~100%LEL/0~100.0vol%※2	1%LEL/0.5vol%
	15	Carbon dioxide (CO_2)		0~10000ppm	25ppm

※ 1 In case of specific combination, caution might be necessary in use.
※ 2 The display automatically changes into vol% when the gas of 100% LEL or more is detected.

Multi Gas Detector

Personal multi gas monitor

HC or CH_4 | O_2 | H_2S | CO

GX-2009

Features

- Simultaneous detection of utmost 4 components possible.
- Protection level: IP67 equivalent.
- Intrinsic safety (explosion-proof class: Exia II CT4X).
- Peak holding function provided.
- Data logger function (utmost 600 hours) equipped.

Explosion-proof ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

HK HK (NIPPON HAKUYOHIN KENTEI KYOKAI)
Prototype approval accepted

MED MED (council directive 96/98/EC on marine equipment) acceptable

Specification

Model	GX-2009			
Detection method	Diffusion type			
Gas to be detected	HC / CH_4	O_2	H_2S	CO
Detection principle	New ceramic	Galvanic cell	Electrochemical	
Detection range	0 ~ 100% LEL	0 ~ 40.0vol%	0 ~ 100.0ppm	0 ~ 500ppm
1 digit	1% LEL	0.1vol%	0.5ppm	1ppm
Alarm setpoint value	1st 10% LEL 2nd 50% LEL OVER 100% LEL	L Alarm 19.5vol% H Alarm 23.5vol% OVER 40.0vol%	1st 5.0ppm 2nd 30.0ppm TWA 5.0ppm STEL 5.0ppm OVER 100.0ppm	1st 25ppm 2nd 50ppm TWA 25ppm STEL 200ppm OVER 500ppm
Range of operating temperature and relative humidity	-20 ~ +50°C and below 85% RH (no condensing)			
Power supply	Ni-MH battery (rechargeable)			
Continuous operating time	Combustible gas detection included: approx. 20 hours (fully charged, 25°C, without alarm nor illumination) Combustible gas detection not included: approx. 60 hours (fully charged, 25°C, without alarm nor illumination)			
External dimension/ Weight	approx. 76(W) × 69(H) × 26(D) mm (projection portions excluded)/approx. 130 g			
Protection level	IP67 equivalent			

Type List

TYPE		Gas to be detected
4 gas	TYPE A	HC or CH_4 / O_2 / H_2S / CO
3 gas	TYPE B	HC or CH_4 / O_2 / H_2S
	TYPE C	HC or CH_4 / O_2 / CO
2 gas	TYPE D	HC or CH_4 / O_2
	TYPE E	O_2 / H_2S
	TYPE F	O_2 / CO
	TYPE I	HC or CH_4 / CO

Handheld multi gas monitor

HC or CH_4 | O_2 | H_2S | CO

GX-2012 GX-2012GT

Features

- 1 ppm of hydrogen sulfide alarm settable.
  (detection of hydrogen sulfide is possible with GX-2012 only).
- Leak of the combustible gas can be checked
  (applicable only for GX-2012GT).
- Intrinsic safety (explosion-proof class: Exia II CT4X).
- Safe protection class for outdoors: IP67 equivalent.
- Alarm lamp easy to see from 3 directions.
- Sound pressure of alarm buzzer not less than 95 dB.
- Dry battery unit (standard) and lithium-ion battery unit (option) can be used together.

Explosion-proof ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

Drawing Pump drawing type

Specification

Model	GX-2012/GX-2012GT				
Detection method	Pump drawing type				
Gas to be detected	HC / CH_4		O_2	H_2S ※1	CO
Detection principle	Hot-wire semiconductor※2	New ceramic/Thermal conductivity	Galvanic cell	Electrochemical	
Detection range	HC : 0 ~ 2000ppm or CH_4 : 0 ~ 5000ppm	0 ~ 100% LEL/~ 100vol%※3	0 ~ 40.0vol%	0 ~ 100.0ppm	0 ~ 500ppm
Alarm setpoint value	-	1st 10% LEL 2nd 50% LEL OVER 100% LEL	L Alarm 19.5vol% H Alarm 23.5vol% OVER 40.0vol%	1st 5.0ppm 2nd 30.0ppm TWA 5.0ppm STEL 5.0ppm OVER 100.0ppm	1st 25ppm 2nd 50ppm TWA 25ppm STEL 200ppm OVER 500ppm
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (Non-condensing)				
Power supply	Dry battery unit <3 AA alkaline battery> (standard) or lithium-ion battery unit (option)				
Continuous operating time	Dry battery unit: approx. 15 hours (25°C, without alarm nor illumination)※4 Lithium-ion battery unit: approx. 10 hours (fully charged, 25°C, without alarm nor illumination)※4				
External dimension/ Weight	approx. 71(W) × 173(H) × 43(D) mm (projection portions excluded)/approx. 360 g (dry battery unit or lithium-ion battery unit installed)				
Protection level	IP67 equivalent				

※1 Detection of hydrogen sulfide is possible with GX-2012 only. ※2 Detection of Leakage (ppm detection) is possible with GX-2012GT only.
※3 Detection of high density combustible gas (vol%) is possible with the CH_4 specification model only. ※4 Continuous operating time of the GX-2012GT varies depending on the mode used.

Type List (GX-2012)

TYPE		Gas to be detected
5 gas	TYPE A	CH_4(% LEL) / CH_4(vol%) / O_2 / H_2S / CO
4 gas	TYPE B	HC or CH_4(% LEL) / O_2 / H_2S / CO
3 gas	TYPE C	HC or CH_4(% LEL) / O_2 / H_2S
	TYPE D	HC or CH_4(% LEL) / O_2 / CO
	TYPE E	CH_4(% LEL) / CH_4(vol%) / O_2
2 gas	TYPE F	HC or CH_4(% LEL) / O_2

Type List (GX-2012GT)

TYPE		Gas to be detected
5 gas	TYPE A	CH_4(leakage) / CH_4(% LEL) / CH_4(vol%) / O_2 / CO
4 gas	TYPE B	HC or CH_4(leakage) / HC or CH_4(% LEL) / O_2 / CO
	TYPE C	CH_4(leakage) / CH_4(% LEL) / CH_4(vol%) / O_2
3 gas	TYPE D	HC or CH_4(leakage) / HC or CH_4(% LEL) / O_2

Multi Gas Detector

Conforming to SOLAS convention amendments! Infrared portable gas monitor series

Combustible gases can be measured even in the inert gas and N2.

Features

- Simultaneous detection and display of combustible gas and oxygen possible.
- Intrinsic safety.
- Continuous operating time up to more than 10 hours.
- Residual CO_2 density in the repairing tank is measurable (RX-8500).
- High density hydrogen sulfide is measurable (RX-8700).

RX-8000

Explosion-proof — ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

MED — MED (council directive 96/98/EC on marine equipment) acceptable

Drawing — Pump drawing type

Specification

Model	RX-8000	
Measuring method	Pump drawing type	
Gas to be detected	HC / CH_4	O_2
Measuring principle	Non-dispersive infrared	Galvanic cell
Measuring range	0 ~ 100.0%LEL / ~ 100.0vol% Automatic range switching	0 ~ 40.0vol%
1 digit	0.5%LEL / 0.5vol%	0.1vol%
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)	
Power supply	Lithium-ion battery unit or dry battery unit <3 AA alkaline battery>	
Continuous operating time	Lithium-ion battery unit: approx. 15 hours (fully charged, 25°C, without alarm nor illumination) dry battery unit: approx. 10 hours (25°C, without alarm nor illumination)	
External dimension/ Weight	approx. 154(W) × 81(H) × 127(D) mm (projection portions excluded)/approx. 1.1 kg (lithium-ion battery unit is used) and (mm) 1.0 kg (dry battery unit is used).	
Protection level	IP67 equivalent	

Simultaneous measurement and display of 4 components is possible and corresponds to all the applications by 1 unit.

RX-8500

Explosion-proof — ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

Drawing — Pump drawing type

Specification

Model	RX-8500			
Measuring method	Pump drawing type			
Gas to be detected	CH_4	O_2	CO	CO_2
Measuring principle	Non-dispersive infrared	Galvanic cell	Electrochemical	Non-dispersive infrared
Measuring range	0 ~ 100.0%LEL/5 ~ 100.0vol% Automatic range switching	0 ~ 40.0vol%	0 ~ 1000ppm	0 ~ 20.0vol%
1 digit	0.5%LEL/0.5vol%	0.1vol%	1ppm	0.01vol% (0 ~ 2.00vol%) 0.05vol% (2.00 ~ 5.00vol%) 0.1vol% (5.00 ~ 20.0vol%)
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)			
Power supply	Lithium-ion battery unit or dry battery unit <3 AA alkaline battery>			
Continuous operating time	Lithium-ion battery unit: approx. 15 hours (fully charged, 25°C, without alarm nor illumination) Dry battery unit: approx. 8 hours (new dry battery, 25°C without alarm nor illumination).			
External dimension/ Weight	approx. 154(W) × 81(H) × 163 (D) mm (projection portions excluded)/ approx. 1.2 kg (lithium-ion battery unit is used) and approx. 1.1 kg (dry battery unit is used)			
Protection level	IP67 equivalent			

High concentration hydrogen sulfide can be measured!
Low and high concentration measuring modes can be switched with only 1 button.

RX-8700

Explosion-proof — ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

Drawing — Pump drawing type

Specification

Model	RX-8700			
Measuring method	Pump drawing type			
Gas to be detected	HC	O_2	H_2S	
Measuring principle	Non-dispersive infrared	Galvanic cell	Electrochemical	
Measuring range	0 ~ 100.0%LEL/2 ~ 100.0vol% Automatic range switching	0 ~ 40.0vol%	[low concentration] 0 ~ 100.0ppm	[high concentration] 0 ~ 1000ppm
1 digit	0.5%LEL/0.5vol%	0.1vol%	0.5ppm	1ppm
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)			
Power supply	Lithium-ion battery unit or dry battery unit (3 AA alkaline battery)			
Continuous operating time	Lithium-ion battery unit: approx. 15 hours (fully charged, 25°C, without alarm nor illumination) Dry battery unit: approx. 8 hours (new dry battery, 25°C without alarm nor illumination)			
External dimension/ Weight	approx. 154(W) × 81(H) × 163 (D) mm (projection portions excluded)/ approx. 1.3 kg (lithium-ion battery unit is used) and approx. 1.1 kg (dry battery unit is used)			
Protection level	IP67 equivalent			

Multi Gas Detector

Simultaneous detection and display of utmost 4 components possible

GX-8000

Explosion-proof — ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

HK — HK (NIPPON HAKUYOHIN KENTEI KYOKAI)
Prototype approval accepted

MED — MED (council directive 96/98/EC on marine equipment) acceptable

Drawing — Pump drawing type

Features

- Easy carrying due to small size and lightness.
- Large screen with backlight easy to see.
- Display the concentration with both the value and the bar meter.
- Solid structure strong to impact and dirt.

Specification

Type	GX-8000			
Detection method	Pump drawing type			
Gas to be detected	HC/CH_4/H_2/C_2H_2	O_2	H_2S	CO
Detection principle	New ceramic/ Thermal conductivity	Galvanic cell	Electrochemical	
Detection range	0 ~ 100% LEL/ ~ 100vol%※	0 ~ 40.0vol%	0 ~ 100.0ppm	0 ~ 500ppm
1 digit	1% LEL/1vol%	0.1vol%	0.5ppm	1ppm
Alarm setpoint value	1st 10% LEL 2nd 50% LEL OVER 100% LEL	L Alarm 19.5vol% H Alarm 22.5vol% OVER 40.0vol%	1st 5.0ppm 2nd 30.0ppm TWA 10.0ppm STEL 15.0ppm OVER 100.0ppm	1st 25ppm 2nd 50ppm TWA 25ppm STEL 200ppm OVER 500ppm
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)			
Power supply	Lithium-ion battery unit (standard) or dry battery unit <3 AA alkaline battery> (option)			
Continuous operating time	Lithium-ion battery unit: approx. 12 hours (fully charged, 25°C, without alarm nor illumination) Dry battery unit: approx. 6 hours (25°C, without alarm nor illumination)			
External dimension/ Weight	approx. 154(W) × 81(H) × 127(D) mm (projection portions excluded)/ approx. 1.1 kg (lithium-ion battery unit is used) and approx. 1.0 kg (dry battery unit is used)			
Protection level	IP67 equivalent			

※Detection of high density combustible gas (vol%) is applicable, only for the CH_4 specification model.

Type List

TYPE		Gas to be detected
4 gas / 5 range	TYPE A	HC or CH_4 (%LEL, vol%) / O_2 / H_2S / CO
4 gas	TYPE B	HC or CH_4 (%LEL) / O_2 / H_2S / CO
3 gas	TYPE C	HC or CH_4 or C_2H_2 (%LEL) / O_2 / H_2S
	TYPE D	HC or CH_4 (%LEL) / O_2 / CO
2 gas / 3 range	TYPE E	HC or CH_4 or H_2 (%LEL, vol%) / O_2
2 gas	TYPE F	HC or CH_4 or C_2H_2 (%LEL) / O_2
	TYPE G	H_2 (%LEL) / O_2

Oxygen Monitor

Portable oxygen monitor

OX-07

Explosion-proof — ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT3X

HK — HK (NIPPON HAKUYOHIN KENTEI KYOKAI) Prototype approval accepted

MED — MED (council directive 96/98/EC on marine equipment) acceptable

Features

- Intrinsic safety.
- Large screen digital display.
- 30 m telemetry possible with remote cable.
- Robust protection rubber for impact equipped as the standard.

Specification

Model	OX-07	
Type	TYPE A	TYPE B
Detection method	Diffusion type	
Gas to be detected	O_2	
Detection principle	Galvanic cell	
Detection range	0 ~ 40.0vol%	
1 digit	0.1 vol%	
Alarm setpoint value	Low alarm 19.5 vol% High alarm 23.5 vol% Over 40.0 vol%	No alarm
Range if operating temperature and relative humidity	-20 ~ +50°C and below 95 RH (non-condensing)	
Power supply	2 AA alkaline battery	
Continuous operating time	approx.5000 hours (25°C without alarm nor illumination)	
External dimension/ Weight	approx. 77(W) x 131(H) x 40(D) mm (projection portions excluded) / approx. 230 g (clip is excluded)	

Portable oxygen monitor

GX-8000 (TYPE O_2)

Explosion-proof — ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

HK — HK (NIPPON HAKUYOHIN KENTEI KYOKAI) Prototype approval accepted

MED — MED (council directive 96/98/EC on marine equipment) acceptable

Drawing — Pump drawing type

Features

- Explosion-proof for hydrogen: Exia II CT4X and safe protection class even under a severe environment IP67 equivalent.
- Strong drawing with a large flow rate pump.
- An extension hose 30 m at the maximum can be used.

Specification

Model	GX-8000
Type	TYPE O_2, L (gas alarm provided specification)
Detection method	Pump drawing type
Gas to be detected	O_2
Detection principle	Galvanic cell
Detection range	0 ~ 40.0vol%
1 digit	0.1vol%
Alarm setpoint value	L Alarm 19.5% H Alarm 23.5% OVER 40.0%
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)
Power supply	Dry battery unit <3 AA alkaline battery> (standard) or lithium-ion battery unit (option)
Continuous operating time	Dry battery unit: approx. 12 hours (25°C, without alarm nor illumination) Lithium-ion battery unit: approx. 20 hours (fully charged, 25°C, without alarm nor illumination)
External dimension / Weight	approx. 154(W) × 81(H) × 127(D) mm (projection portions excluded) / approx. 1.0 kg (dry battery unit used) and approx. 1.1 kg (lithium-ion battery used)
Protection level	IP67 equivalent

Combustible Gas Detector

Handheld gas leakage detector

SP-220

Explosion-proof

TYPE M For City gas (CH_4)
TYPE L For LPG
TYPE ML For both City gas (CH_4) and LPG
TYPE F For CFC gas
TYPE H2 For Hydrogen and combustible gas

Non Explosion-proof

TYPE FUM For Fumigation gas
TYPE SC For Semiconductor material gas and general gas

Features

- Target gas changeable
- Quick and reliable detection for small amount of gas leakage.
- Strong for impact and dirt, robust and stylish body.
- The durability of the sensor has been improved with a built-in filter.
- Data logger function equipped (256 data at the maximum can be recorded).
- Safe even in a dark place with the LED light.

Explosion-proof: ATEX, TIIS Explosion-proof authorized *
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4
※TYPE M/TYPE L/TYPE ML/TYPE F/TYPE F only

Drawing: Pump drawing type

List of Gas to be Detected

●For CFC gas (TYPE F)

1	R600a (isobutane)	8	CFC 23
2	R290 (propane)	9	CFC 407C
3	CFC 123	10	CFC 410A
4	CFC 134a	11	CFC 404A
5	CFC 142b	12	2,3,3,3-Tetrafluoropropane (HFO-1234yf)
6	CFC 22	13	CFC 507A
7	CFC 32	14	CFC 407A

●For Hydrogen and combustible gas (TYPE H2)

1	Methane	8	Butadiene	15	CFC 134a
2	Hydrogen	9	Isobutylene	16	HFO-1234yf
3	Acethylene	10	n-butane		
4	Ethylene	11	Isobutane		
5	Ethane	12	Cyclopentane		
6	Propylene	13	n-hexane		
7	Propane	14	CFC 22		

●For fumigation gas (TYPE FUM)

1	Phosphine
2	Methyl bromide
3	Carbon disulfide※
4	Methyl iodide
5	Hydrogen cyanide
6	Sulfuryl fluoride
7	Ethylene dibromide※

※ Prohibited gas to use in Japan.

●For Semiconductor material gas and general gas (TYPE SC)

1	Phosphine	11	Methyl chloride	21	Propane	31	Hydrogen sulfide
2	Acetone	12	Xylene	22	CFC 134a	32	Diborane
3	Arsine	13	Ethylene oxide	23	CFC 22	33	Germane
4	Ammonia	14	Silane	24	CFC 32	34	Hydrogen bromide
5	Isobutane	15	Methyl bromide	25	Normal hexane	35	Hydrogen chloride
6	Isopropyl alcohol	16	Hydrogen	26	Benzene	36	CFC 407C
7	Carbon monoxide	17	Trichloroethylene	27	Formaldehyde	37	Hydrogen selenide
8	Ethyl alcohol	18	Toluene	28	Methane	38	CFC 410A
9	Ethylene	19	1, 2-Dichloroethane	29	Methyl alcohol	39	CFC 404A
10	Vinyl chloride	20	Sulfur dioxide	30	Methyl ethyl ketone	40	HFO-1234yf

Specification

Model	SP-220						
Type	TYPE M	TYPE L	TYPE ML	TYPE F	TYPE H2	TYPE FUM	TYPE SC
Detection method	Pump drawing type						
Gas to be detected	City gas	LPG	City gas / LPG (switch)	Refer to the "List of gas to be detected" above			
Calibration gas	CH_4	i-C_4H_{10}	CH_4/i-C_4H_{10}※	i-C_4H_{10}	H_2/CH_4	PH_3	
Detection principle	Hot-wire semiconductor						
Detection range	10 ~ 10000ppm			Depending on gas to be detected			
Alarm setpoint value	Initial value: 30 ppm (possible to set by 5 steps of 10, 30, 150, 500, and 2000 ppm)					Depending on gas to be detected	
Range of operating temperature and relative humidity	-20 ~ +55°C and below 95% RH (non-condensing)						
Power supply	2 AA alkaline battery						
Continuous operating time	approx. 13 hours (20°C, without alarm nor illumination)						
External dimension/ Weight	approx. 43(W) × 200(H) × 39(D) mm (the taper nozzle is excluded)/approx. 215 g (dry battery is excluded).						
Protection class	IP55 equivalent						

※Gas Calibration

Combustible Gas Detector

Portable combustible gas monitor

【For LEL detection】 【For ppm detection】

GP-1000 / NC-1000

【For VOL detection】

NP-1000

Explosion-proof ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4

Drawing Pump drawing type

GP-1000/NC-1000 List of Gas to be detected

No.	List of Gas kind	Display	Lower Explosive Limit LEL	Reading from methane in a different way	Reading from isobutane in a different way
1	Methane	CH_4	5.0vol%	—	×
2	Isobutane	$i\text{-}C_4H_{10}$	1.8vol%	○	—
3	Hydrogen	H_2	4.0vol%	○	○
4	Methanol	CH_3OH	5.5vol%	○	○
5	Acetylene	C_2H_2	1.5vol%	○	○
6	Ethylene	C_2H_4	2.7vol%	○	○
7	Ethane	C_2H_6	3.0vol%	○	×
8	Ethanol	C_2H_5OH	3.3vol%	○	○
9	Propylene	C_3H_6	2.0vol%	○	○
10	Acetone	C_3H_6O	2.15vol%	○	○
11	Propane	C_3H_8	2.0vol%	○	×
12	Butadiene	C_4H_6	1.1vol%	○	○
13	Cyclopentane	C_5H_{10}	1.4vol%	○	○
14	Benzene	C_6H_6	1.2vol%	○	○
15	n-hexane	$n\text{-}C_6H_{14}$	1.2vol%	○	○
16	Toluene	C_7H_8	1.2vol%	○	○
17	Heptane	$n\text{-}C_7H_{16}$	1.1vol%	○	○
18	Xylene	C_8H_{10}	1.0vol%	○	○
19	Ethyl acetate	EtAc	2.1vol%	○	○
20	IPA	IPA	2.0vol%	○	○
21	MEK	MEK	1.8vol%	○	○
22	Methyl methacrylate	MMA	1.7vol%	○	○
23	Dimethyl ether	DME	3.0vol%	○	○
24	Methyl isobutyl ketone	MIBK	1.2vol%	○	○
25	Tetrahydrofuran	THF	2.0vol%	○	○

Note 1) The alarm accuracy and response time, etc. are confirmed only by the calibration gas.
Note 2) Please contact RIKEN KEIKI in the case that calibration with other than methane, isobutane and hydrogen is required.
Note 3) Please note that switching of kind of detection gas is impossible if the calibration is implemented using other than methane and isobutane.

NP-1000 List of Gas to be detected

No.	List of Gas kind	Display
1	Methane	CH_4
2	Propane	C_3H_8
3	Isobutane	$i\text{-}C_4H_{10}$
4	Argon	Ar
5	Helium	He
※	Hydorogen	H_2

※Hydrogen is detected by NP-1000 H_2 version. H_2 version cannot convert the reading to other gases.

NP-1000 List of Base Gas

No.	List of Gas kind	Display
1	Air	Air
2	Nitrogen	N_2
3	Carbon dioxide	CO_2

Features

- Direct reading of the concentration values of combustible gases of 25 gases.
- Easy operation feature of changing the gas name display with 1 switch button.
- Long distance drawing possible with the pump booster function.
- Various combustible gases can be measured by the ppm order with NC-1000.

Specification

Model	GP-1000	NC-1000	NP-1000
Detection method	Pump drawing type		
Gas to be detected	Combustible gas and others		
Detection principle	Catalytic combustion	New ceramic	Thermal conductivity
Detection range	0 ～ 100% LEL <Automatic range switching> Low range : 0 ～ 10% LEL High range : 0 ～ 100% LEL	0 ～ 10000ppm <Automatic range switching> Low range : 0 ～ 1000ppm High range : 0 ～ 10000ppm	0 ～ 100 Vol% <Automatic range switching> Low range : 0 ～ 10 Vol% High range : 0 ～ 100 Vol%
Alarm setpoint value	1st 10% LEL 2nd 50% LEL	1st 250ppm 2nd 500ppm	Factory setting : OFF
Range of operating temperature and relative humidity	-20 ～ +50°C and below 95% RH (non-condensing)		
Power supply	4 AA alkaline battery		
Continuous operating time	approx. 20 hours※ (new dry battery, 25°C, without alarm nor illumination, and pump Low mode)		
External dimension/ Weight	approx. 80(W) × 124(H) × 36(D) mm (projection portions excluded) / approx. 260 g (dry battery is excluded).		
Protection level	IP67 equivalent		

※Different depending on the specification

For the Protection of Explosion due to Leakage of Combustible Gases

Combustible Gas Detector

Portable combustible gas monitor

GX-8000 (TYPE LEL)

Explosion-proof

ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4X

HK

HK (NIPPON HAKUYOHIN KENTEI KYOKAI) Prototype approval accepted

MED

MED (council directive 96/98/EC on marine equipment) acceptable

Drawing

Pump drawing type

Features

- Explosion-proof for hydrogen : Exia II CT4X, and safe protection class even under a severe environment IP67 equivalent.
- Strong drawing with a large flow rate pump.
- An extension hose 30 m at the maximum can be used.

Specification

Model	GX-8000
Type	TYPE LEL
Detection method	Pump drawing type
Gas to be detected	HC / CH_4 / H_2
Detection principle	New ceramic
Detection range	0 ~ 100% LEL
1 digit	1% LEL
Alarm setpoint value	1st : 10% LEL, 2nd : 50% LEL, OVER : 100% LEL
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)
Power supply	Dry battery unit <3 AA alkaline battery> (standard) or lithium-ion battery unit (option)
Continuous operating time	Dry battery unit: For approx. 6 hours (25°C, without alarm nor illumination) Lithium-ion battery unit: For approx. 12 hours (fully charged, 25°C, without alarm nor illumination)
External dimension/ Weight	approx. 154(W) × 81 (H) × 127 (D) mm (projection portions excluded) / approx. 1.0 kg (dry battery unit used) and approx. 1.1 kg (lithium-ion battery used)
Protection level	IP67 equivalent

Wide Variation of Usage

Super Toxic Gas Detector

For the patrol such as semiconductor factories

Portable super toxic gas detector

SC-8000

Features

- Intrinsic safety.
- Diverse target gases.
- Simultaneous display of gas concentration with digital numbers and gas concentration level with analog bar meter.
- Buzzer volume control function equipped.

Explosion-proof

ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4

HK

HK (NIPPON HAKUYOHIN KENTEI KYOKAI) Prototype approval accepted

Drawing

Pump drawing type

Gas to be Detected

PH_3	HCl	HF	F_2	ClF_3	HI
AsH_3	Br_2	CO	NH_3	HCN	H_2S
SiH_4	NO	Cl_2	HBr	PF_3	SO_2
B_2H_6	NO_2	O_3	H_2Se	GeH_4	

Specification

Model	SC-8000
Detection method	Pump drawing type
Gas to be detected	Refer to the list of target gases above
Detection principle	Electrochemical
Detection range	Depending on gas to be detected
1 digit	
Alarm setpoint value	
Range of operating temperature and relative humidity	-20 ~ +50°C and 20- 88% RH (no condensing)
Power supply	Dry battery unit <3 AA alkaline battery> (standard) or lithium-ion battery unit (option)
Continuous operating time	Dry battery unit: For approx. 18 hours (25°C, without alarm nor illumination) Lithium-ion battery unit: For approx. 25 hours (fully charged, 25°C, without alarm nor illumination)
External dimension/ Weight	approx. 154(W) × 154(H) × 81(D) mm (projection portions excluded) / approx. 1.0 kg (dry battery unit used) and approx. 1.1 kg (lithium-ion battery used)
Protection level	IP67 equivalent

Portable toxic gas monitor

SC-01

Explosion-proof

ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II BT3

Gas to be Detected

H_2S	NH_3	SO_2
Cl_2	HCN	PH_3
CO		

Features

- Intrinsic safety.
- Telemetry possible with remote cable.
- Robust protection rubber for impact equipped as the standard.

Specification

Model	SC-01
Detection method	Diffusion type
Gas to be detected	Refer to the table left
Detection principle	Electrochemical
Detection range	Depending on gas to be detected
1 digit	
Alarm setpoint value	
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)
Power supply	2 AA alkaline battery
Continuous operating time	For approx. 250 hours (25°C without alarm nor illumination)
External dimension/ Weight	approx. 77(W) × 131(H) × 40(D) mm (projection portions excluded)/approx. 240 g

Small Personal Size

Single Gas Detector

Personal gas monitor

03 series

Features

- Simple design not to disturb work.
- Light body of approx. 80 g with Intrinsic safety.
- Rechargeable battery (eneloop) specification lined up.

Explosion-proof

ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4 (GP-03, CO-03, HS-03)
Exia II CT4X (OX-03)
Exia II CT3Ga (rechargeable battery specification)

Specification

Model	GP-03	OX-03	CO-03	HS-03
Detection method	Diffusion type			
Gas to be detected	HC / CH_4	O_2	CO	H_2S
Detection principle	New ceramic	Galvanic cell	Electrochemical	Electrochemical
Detection range	0 ~ 100% LEL	0 ~ 40.0vol%	0 ~ 500ppm	0 ~ 100.0ppm
1 digit	1% LEL	0.1vol%	1ppm	0.5ppm
Alarm setpoint value	1st 10% LEL 2nd 50% LEL OVER 100% LEL	L Alarm 19.5vol% H Alarm 23.5vol% OVER 40.0vol%	1st 25ppm 2nd 50ppm TWA 25ppm STEL 200ppm OVER 500ppm	1st 5.0ppm 2nd 30.0ppm TWA 5.0ppm STEL 5.0ppm OVER 100.0ppm
Range of operating temperature and relative humidity	-20 ~ +50℃ Below 90% RH (no condensing)	-20 ~ +50℃ Below 95% RH (no condensing)	-20 ~ +50℃ 16 - 85% RH (no condensing)	
Power supply	2 AAA alkaline battery			
Continuous operating time*	For approx. 35 hours (25°C, without alarm nor illumination)	For approx. 3000 hours (25°C without alarm nor illumination)		
External dimension/ Weight	approx. 54(W) × 67(H) × 24(D) mm approx. 80 g			

※When dry battery is used.

From the Environment Measurement to the Leakage Detection

Miscellaneous Monitors

Formaldehyde gas monitor

FP-31

Ministry of Health, Labour and Welfare certified product (JAPAN)
Specified number 2701 ※1

Features

- Everyone can measure it by an easy operation.
- No anxiety owing to self-diagnosis function installed, and it is safety, and little interference influences.
- Large screen and big letters display easy to see.

Drawing Pump drawing type

Specification

Model	FP-31	
Detection method	Pump drawing type	
Gas to be detected	HCHO (formaldehyde)	
Detection principle	Photoelectric photometry method	
Detection range	TAB No.008	TAB No.009
	0.000 ~ 0.400ppm (however, less than 0.015 ppm is displayed to be < 0.01)	0.00 ~ 1.00ppm (however, less than 0.02 ppm is displayed to be < 0.02)
1 digit	0.005ppm	0.01ppm
Detection time	30 minutes (1800 seconds)	15 minutes (900 seconds)
Range of operating temperature and relative humidity	-10 ~ +40°C and below 90% RH (non-condensing)※2	
Power supply	4 AA alkaline battery	
Continuous operating time	For about 12 hours (new dry battery, 20°C without alarm nor illumination)	
External dimension / Weight	approx. 80(W) × 150(H) × 40(D) mm (projection portions excluded) / approx. 250 g (dry battery is excluded)	

※1 Never fail to use TAB No.008 (0 ~ 0.4ppm) when formaldehyde is to be detected according to the concentration in a room guideline value (0.08 ppm/100 μg/m³ as the average for 30 minutes) of WHO and the Ministry of Health, Labour and Welfare.
※2 Range of operating temperature and relative humidity of detection TAB is described to each detection TAB.

Gas Concentration Meter

For the accurate measurement of various gas concentrations

Optical interterometric gas concentration meter

FI-8000

Explosion-proof ATEX, TIIS Explosion-proof authorized
Explosion-proof construction: Intrinsic safety
Explosion-proof class: Exia II CT4

Drawing Pump drawing type

Features

- Up to 8 gases can be measured simultaneously with 1 instrument.
- Gas drawing method can be chosen (automatic drawing with pump or manual drawing).
- Continuous / intermittent measuring mode are installed.

Specification

Model	FI-8000	
Type	TYPE P	TYPE A
Measuring method	Automatic drawing type with built-in pump	Manual drawing type with hand aspirator
Gas to be detected	Anaesthetic gas / Fumigation gas / Combustible gas / Calorific value etc.	
Measuring principle	Optical inferferometric	
Measuring range	Depending on the measuring object gas	
Indication accuracy	±3% of reading (under the same condition)※	
Range of operating temperature and relative humidity	-20 ~ +50°C and below 95% RH (non-condensing)	
Power supply	Dry battery unit <3 AA alkaline battery> (standard) or lithium-ion battery unit (option)	
Continuous operating time	For approx. 12 hours (new dry battery, 25°C, without illumination)	For approx. 16 hours (new dry battery, 25°C, without illumination)
External dimension/ Weight	approx. 154(W) × 81(H) × 127(D) mm (projection portions excluded) approx. 1.1 kg (dry battery unit is used) and approx. 1.2 kg (lithium-ion battery unit is used)	
Protection level	IP67 equivalent	

※The indication accuracy is different depending on the measuring object gas.

Measuring gas list

<Chamber length: 5mm>

Gas to be detected	Base gas	Range
Methyl bromide	Air	0~100vol%
Sulfur Hexafluoride	Air	0~100vol%
Sulfur Hexafluoride	Air	0~99.9%up
Sulfur Hexafluoride	N_2	0~100vol%
Propane	Air	0~100vol%
Iso-butane	Air	0~100vol%
N-butane	Air	0~100vol%
Flon 22	Air	0~100vol%
Dimethyl Ether	Air	0~100vol%
Dimethyl Ether	N_2	0~100vol%
Xenon	Air	0~100vol%
Ethylene	Air	0~100vol%
Chorine	Air	0~100vol%
Vinyl chloride	N_2	0~100vol%

Gas to be detected	Base gas	Range
Propane	Air	0~101.3 MJ/m³ Gross 0℃
Butane	Air	0~134.2 MJ/m³ Gross 0℃
Propane	Air	0~93.15 MJ/m³ Net 0℃
Butane	Air	0~123.7 MJ/m³ Net 1℃

Detection gas for anaesthetic

Detection gas for fumigation

<Chamber length: 24mm>

Gas to be detected	Base gas	Range
Halothane	O_2	0~6vol%
Isoflurane	O_2	0~8vol%
Sevoflurane	O_2	0~10vol%
Desflurane	O_2	0~20vol%
Halothane	Air	0~6vol%
Isoflurane	Air	0~8vol%
Sevoflurane	Air	0~10vol%
Desflurane	Air	0~20vol%
Enflurane	O_2	0~10vol%
Enflurane	Air	0~10vol%

Gas to be detected	Base gas	Range
Helium	Air	0~100vol%
Helium	N_2	0~100vol%
Helium	Argon	0~100vol%
Hydrogen	Air	0~100vol%
Hydrogen	N_2	0~100vol%
Heavy Hydrogen	Air	0~100vol%
Heavy Hydrogen	N_2	0~100vol%
Carbon dioxide	Air	0~100vol%
Carbon dioxide	N_2	0~100vol%
Carbon dioxide	Argon	0~100vol%
Neon	Air	0~100vol%
Methane	Air	0~100vol%
Methane	N_2	0~100vol%
Nitrus Oxide	Air	0~100vol%
Ozone	O_2	0~100vol%

Gas to be detected	Base gas	Range
LNG or LNG+LPG	-	25~50 MJ/m³ Gross 0℃
LNG or LNG+LPG	-	22~45 MJ/m³ Net 0℃

<Chamber length: 48mm>

Gas to be detected	Base gas	Range
Toluene	Air	0~100%LEL
MEK	Air	0~100%LEL
Ethyl acetate	Air	0~100%LEL
Xylene	Air	0~100%LEL
Iso-proply alcohol	Air	0~100%LEL
M.E.K	Air	0~100%LEL
Methanol	Air	0~100%LEL
Propane	Air	0~100%LEL
Iso-butane	Air	0~100%LEL
Acetone	Air	0~100%LEL
Ethyl alcohol	Air	0~100%LEL
Methane	Air	0~100%LEL
Hydrogen	Air	0~100%LEL
Ethyl chloride	Air	0~100%LEL
Ethylene	Air	0~100%LEL
Styrene	Air	0~100%LEL
Ammonia	Air	0~100%LEL
Tetrahydroflane	Air	0~100%LEL
Dioxolane	Air	0~100%LEL
Methyl-isopropil-Keton	Air	0~100%LEL
Tetrafluoro-propane	Air	0~100%LEL
Butylacetate	Air	0~100%LEL

Gas to be detected	Base gas	Range
Methyl Bromide	Air	0~200g/m³
Methyl Iodide	Air	0~200g/m³
Sulfuryl Fluoride	Air	0~200g/m³
Methyl Bromide	Air	0~5vol%
Propylene oxide	Air	0~10vol%
Phosphine	Air	0~50g/m³
Hydrogen Cyanide	Air	0~200g/m³

Gas to be detected	Base gas	Range
Ammonia	N_2	0~100vol%
Oxygen	N_2	0~100vol%

Danger of Gas

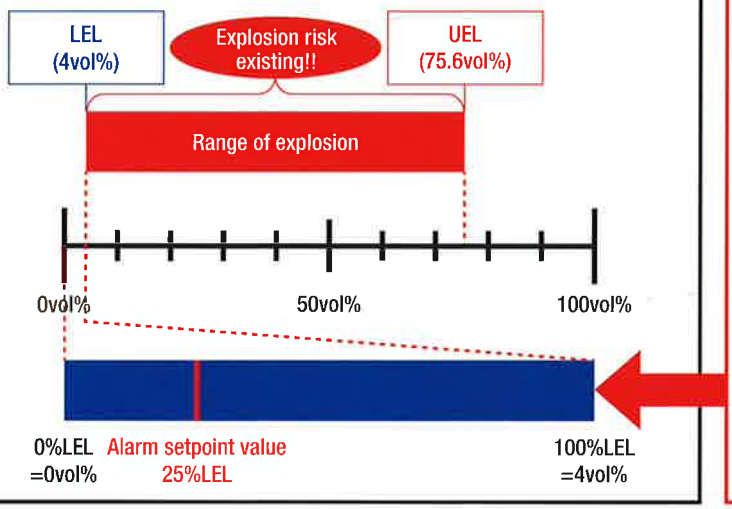
What is the Combustible Gas ...?

According to Safety Regulations for General High Pressure Gas (JAPAN), the combustible gas is;

- The lower limit of the explosion limit of it (it means the explosion limit when it is mixed with air. It is the same as follows.) is 10-percent or less.
- The difference between upper limit and lower limit of explosion limit of it is 20 percent or larger.

The combustible gas is a generic name of the gas with the possibility of causing combustion. There is a possibility of causing an explosion if the density range of the mixture of combustible gas and Oxygen (air) is in a certain range and ignition source exists. This density range is called the range of explosion, and the lowest concentration over the range of explosion is called Lower Explosive Limit (LEL) and the highest concentration are called Upper Explosive Limit (UEL).

1 Example of Lower Explosive Limit (LEL) and Upper Explosive Limit (UEL) of Hydrogen (H_2)



Regarding the Alarm Setpoint Value of the Combustible Gas

It is too late to annunciate the danger after the concentration of the combustible gas reaches Lower Explosive Limit (LEL)!!

The concentration control to inform the existence of the combustible gas before it reaches LEL is necessary.

Regarding the concentration control of less than the Lower Explosive Limit, the alarm setpoint value of the combustible gas is decided as follows in Exemplified Standards concerning Safety Regulations for General High Pressure Gas.

- The value of 1/4 or less of the Lower Explosive Limit

What is the Toxic Gas ...?

According to Safety Regulations for General High Pressure Gas (JAPAN), the toxic gas is,

- Threshold limit value is the 1 of 200/1,000,000 or less (= permissible level is 200 ppm or less)

Moreover, the alarm setpoint value of the toxic gas, according to Exemplified Standards concerning Safety Regulations for General High Pressure Gas, is

- The value below the permissible level value (twice value of the permissible level concentration value for the 1 which is difficult to prepare the calibration gas)

● Definition of permissible level

It is a concentration judged for the adverse effect on health not to be seen by almost all workers if the concentration of the toxic substance in air is below this value even if the worker is exposed to the toxic substance on the labor site.

RIKEN KEIKI adopts the threshold limit value of ACGIH (The United States industry hygiene expert meeting: American Conference of Governmental Industrial Hygienists) though the threshold limit value is recommended by ACGIH and Japan Association of Industrial Health.

● Kind of threshold limit value

- TWA (time weighted average): Time-weighted average value of that health problems might not be caused even if exposed repeatedly in the usual work of 8 hours per day, 40 hours during the week.
- STEL (short term exposure limit): Limit value of short time exposure 4 times or less a day within 15 minutes and interval of 1h or more, by which no health problems might be caused.
- C (ceiling value): Upper bound that must not be exceeded.

What are Oxygen Deficiency and the Hydrogen Sulfide Poisoning?

Oxygen Deficiency and the hydrogen sulfide poisoning are provided from Ordinance on Prevention of Oxygen Deficiency, etc. as follows.

- Oxygen Deficiency ..... The symptom that occurs because of inhalation of air in the state whose concentration of the atmospheric oxygen is less than 18% is observed.
- Hydrogen sulfide poisoning .... The symptom that occurs because of inhalation of air in the state whose concentration of the hydrogen sulfide exceeds 10/1,000,000 (10 ppm) is observed.

A usual alarm setpoint value is set to 18% according to Ordinance on Prevention of Oxygen Deficiency, etc (JAPAN).

Symptom of Oxygen Deficiency

Oxygen concentration (%)	Symptom
20.93	Oxygen concentration of atmosphere.
18	It is necessary to prepare the respiratory protective device such as continuous ventilation, the oxygen concentration measurements in the work environment, and the safety belts though it is a safety threshold. 
16 ~ 12	Increase of pulse and ventilatory frequency, mental concentration decrease, wrong simple calculation, poor precision muscle work, muscular depression, headache, the tinnitus aurium, the evil intention, and nausea appear. 
14 ~ 9	A judgment decrease, a state of exaltation, an unstable mental status, frequent sigh, abnormal tiredness, the state of drunkenness, headache, nausea, vomits, no memory at that time, pain in the wound not felt, escape power of whole body, temperature elevation, cyanosis, haze consideration, danger of the crash death from stairs and a ladder and drowning. 
10 ~ 6	Nausea, vomitus, loose freedom of the action, cannot move nor shout even if danger is felt, prostration, sensory hallucination, cyanosis, loss of consciousness, fainting, central nervous system disorder, generalized convulsion, crisis of death. 
6 or less	Several-time gasping respirations and syncope, fainting, bradypnea and stop, spasm, cardioplegic arrest, death.

Symptom of Hydrogen Sulfide Poisoning

Hydrogen sulfide concentration (ppm)	Symptom
0.025	Limitation of sense of smell.
0.2	Everyone can perceive the odour.
3 ~ 5	Odour of strength of revolted medium degree.
10	Mucous membrane stimulation thresholds of eyes.
20 ~ 30	Do not feel the strength in a concentration any more by the experience of the odour. Minimum boundary where lungs are stimulated.
100 ~ 300	It comes to be felt that the unpleasant odour decreased rather in 2 to 15 minute due to sense of smell neuroparalysis. Diaphragma flame (gas eyes), itching of eye, soreness, feeling that sand catches one's eye, dazzling, hyperemia and tumescence, turbidity of diaphragma, cornea fracture and sluff, distortion of view or bleariness, enhancement of soreness by light. Dead from suffocation due to bronchitis, pulmonitis and pulmonary oedema with 8 to 48 hrs. continuum exposure. Scorching soreness of mucous membrane of the air passages. Limitation that doesn't arrive at a serious symptom with an exposure of 1 hr. or less. 
350 ~ 600	Danger of the life with an exposure of 30 minutes to 1 hr.
700 ~ 1000	Respiratory paralysis, loss of consciousness, fainting, respiratory stoppage, and death at once after appearance of short time interval breath.
5,000	Instantaneous death. 

Reference : New anoxia danger work chief person text (October 26, 2007 3rd print issued)

List of Combustible Gas to be Detected※

Gas name	Chemical formula	Flash point (℃)	Ignition temperature (℃)	Explosion limit (vol%)		Specific gravity
				Lower limit	Upper limit	
Acetylene	C_2H_2	gas	305	1.5	100	0.9 (gas)
Acetone	C_3H_6O	-20	539	2.15	14.3 100℃	0.8
Isobutane	C_4H_{10}	gas	460	1.8	9.8	0.6
Ethanol	C_2H_6O	12	400	3.3	19	0.8
Ethane	C_2H_6	gas	515	3.0	15.5	1.0 (gas)
Ethylene	C_2H_4	gas	440	2.7	36.0	1.0 (gas)
Ortho-xylene	C_8H_{10}	30	470	1.0	7.6	0.9
Ethyl acetate	$C_4H_8O_2$	-4	470	2.1	12.8	0.9
Cyclohexane	C_6H_{16}	-17	245	1.3	8.3	0.8
Cyclopentane	C_5H_{10}	-37	320	1.4	—	—
Dimethyl ether	C_2H_6O	gas	240	3.0	32	—
Hydrogen	H_2	gas	560	4.0	75	0.07 (gas)
Styrene	C_8H_8	30	490	1.1	8.0	0.9
Tetrahydrofuran	C_4H_8O	-14	230	1.8	12.4	0.9
Toluene	C_7H_8	4	530	1.2	7.8	0.9
1,3-butadiene	C_4H_6	gas	420	1.1	16.3	0.6
Propane	C_3H_8	gas	450	2.0	10.9	1.6 (gas)
Propylene	C_3H_6	gas	455	2.0	11.1	—
n-hexane	C_6H_{14}	-22	223	1.2	7.5	0.7
n-heptane	C_7H_{16}	-7	204	1.1	6.7	0.7
Benzene	C_6H_6	-11	498	1.2	8.6	0.9
Methyl methacrylate	$C_5H_8O_2$	10	430	1.7	12.5	0.9
Methanol	CH_4O	9	440	5.5	36	0.8
Methane	CH_4	gas	600	5.0	15.0	0.6
Methyl isobutyl ketone	$C_6H_{12}O$	16	475	1.2 90℃	8 90℃	0.8

※ The value of each item is different according to the literature. The explosion limit in this list of gas to be detected is described based on the house standard. The flash point and the ignition temperature is according to [technological indicator of Labor health and safety General Institute: JNIOSH-TR-No.44 (2012) Factory explosion-proof facility guide for user] and the specific gravity is according to [danger and harmful handbook of chemical substance, June 20, 1991, 1st ed 1st print Issued]

List of Toxic Gas to be Detected

Gas name	Chemical formula	ACGIH recommendation value			Japan Association of Industrial Health recommendation value	RIKEN KEIKI standard	
		Threshold limit value (TLV)※1			Threshold limit value※1	Detection range※2	Alarm setpoint value※2
		TWA	STEL	C			
Arsine	AsH_3	5ppb	—	—	10ppb	0～15ppb	5ppb
Phosphine	PH_3	0.3ppm	1ppm	—	0.3ppm	0～1ppm	0.3ppm
Diborane	B_2H_6	0.1ppm	—	—	0.01ppm	0～0.3ppm	0.1ppm
Silane	SiH_4	5ppm	—	—	100ppm	0～15ppm	5ppm
Disilane	Si_2H_6	—	—	—	—	0～15ppm	5ppm
Germane	GeH_4	0.2ppm	—	—	—	0～0.8ppm	0.2ppm
Hydrogen selenide	H_2Se	0.05ppm	—	—	0.05ppm	0～0.2ppm	0.05ppm
Nitrogen trifluoride	NF_3	10ppm	—	—	—	0～30ppm	10ppm
Boron tribromide	BBr_3	—	—	1ppm	—	HBr 0～6ppm	HBr 2ppm
Arsenic trichloride	$AsCL_3$	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Arsenic pentachloride	$AsCL_5$	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Boron trichloride	BCL_3	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Germanium tetrachloride	$GeCL_4$	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Molybdenum pentachloride	$MoCL_5$	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Phosphorus trichloride	PCL_3	0.2ppm	0.5ppm	—	0.2ppm	HCL 0～6ppm	HCL 2ppm
Phosphorus pentachloride	PCL_5	0.1ppm	—	—	0.1ppm	HCL 0～6ppm	HCL 2ppm
Phosphorus oxychloride	$POCL_3$	0.1ppm	—	—	—	HCL 0～6ppm	HCL 2ppm
Antimony pentachloride	$SbCL_5$	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Silicon tetrachloride	$SiCL_4$	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Dichlorosilane	SiH_2CL_2	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Trichlorosilane	$SiHCL_3$	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Tin tetrachloride	$SnCL_4$	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Tungsten hexachloride	WCL_6	—	—	—	—	HCL 0～6ppm	HCL 2ppm
Tungsten hexafluoride	WF_6	—	—	—	—	HF 0.4ppm～3ppm	HF 0.5ppm
Arsenic trifluoride	AsF_3	—	—	—	—	HF 0.4ppm～3ppm	HF 0.5ppm
Arsenic pentafluoride	AsF_5	—	—	—	—	HF 0.4ppm～3ppm	HF 0.5ppm
Boron trifluoride	BF_3	—	—	1ppm	0.3ppm	HF 0.4ppm～3ppm	HF 0.5ppm
Molybdenum hexafluoride	MoF_6	—	—	—	—	HF 0.4ppm～3ppm	HF 0.5ppm
Phosphorus pentafluoride	PF_5	—	—	—	—	HF 0.4ppm～3ppm	HF 0.5ppm
Sulfur tetrafluoride	SF_4	—	—	0.1ppm	—	HF 0.4ppm～3ppm	HF 0.5ppm
Silicon Tetrafluoride	SiF_4	—	—	—	—	HF 0.4ppm～3ppm	HF 0.5ppm
Hydrogen chloride	HCL	—	—	2ppm	5ppm	0～6ppm	2ppm
Hydrogen fluoride	HF	0.5ppm	—	2ppm	3ppm	HF 0.4ppm～3ppm	HF 0.5ppm
Hydrogen bromide	HBr	—	—	2ppm	—	0～6ppm	2ppm
Hydrogen iodide	HI	—	—	—	—	0～5ppm	2ppm
Chlorine	CL_2	0.5ppm	1ppm	—	0.5ppm	0～1.5ppm	0.5ppm
Fluorine	F_2	1ppm	2ppm	—	—	0～3ppm	1ppm
Bromide	Br_2	0.1ppm	0.2ppm	—	0.1ppm	0～1ppm	0.2ppm
Chlorine trifluoride	CLF_3	—	—	0.1ppm	—	0～0.6ppm	0.1ppm
Ozone	O_3	0.1ppm	—	—	0.1ppm	0～0.6ppm	0.1ppm
Nitrogen monoxide	NO	25ppm	—	—	—	0～100ppm	25ppm
Nitrogen dioxide	NO_2	0.2ppm	—	—	pending	0～9ppm	3ppm
Sulfur dioxide	SO_2	—	0.25ppm	—	pending	0～6ppm	2ppm／4ppm
Hydrogen sulfide	H_2S	1ppm	5ppm	—	5ppm	0～3ppm	1ppm
Carbon monoxide	CO	25ppm	—	—	50ppm	0～75ppm	25ppm
Ammonia	NH_3	25ppm	35ppm	—	25ppm	0～75ppm	25ppm
Monomethylamine (MMtA)	CH_5N	5ppm	15ppm	—	10ppm	0～15ppm	5ppm
Dimethylamine (DMA)	C_2H_7N	5ppm	15ppm	—	10ppm	0.2～15ppm	5ppm
Trimethylamine (TMA)	C_3H_9N	5ppm	15ppm	—	—	0～15ppm	5ppm
Diethylamine (DEA)	$C_4H_{11}N$	5ppm	15ppm	—	10ppm	0.2～15ppm	5ppm
Hydrogen cyanide	HCN	—	—	4.7ppm	5ppm	0.3～15ppm	5ppm
Hydrogen peroxide	H_2O_2	1ppm	—	—	—	0～3ppm	1ppm／2ppm

※1 Refer to [2013 TLVs R and BEIs R] for the threshold limit value recommended by ACGIH (American Coference of Governmental Industrial Hygienist).
Refer to [Industrial hygiene magazine Journal of Occupational Health Vol 55 No. 5 Issue September, 2013] for the threshold limit value recommended by Japan Association of Industrial Health.
RIKEN KEIKI adopts the threshold limit value of ACGIH.

※2 For the hydrolyzing gas, the range of detection and the alarm setpoint value of the gas generated after the gas is hydrolyzed are described.
TWA (time weighted average): Time-weighted average value of that health problems might not be caused even if exposed repeatedly in the usual work of 8 hours per day, 40 hours during the week.
STEL (short term exposure limit): Limit value of short time exposure 4 times or less a day within 15 minutes and interval of 1h or more, by which no health problems might be caused.
C (ceiling value): Upper bound that must not be exceeded.

Related Laws and Regulations (JAPAN)

In the work environments where combustible gases, toxic gases and other hazardous gases are used, it is mandatory to install gas detector to measure them in order to secure safety. This section provides excerpt of the laws and regulations relating to gas detector.

High Pressure Gas Safety Act (act no. 204 of June 7, 1951)

Latest Amendments: Act No. 66 of September 11, 2015

Chapter I General Provisions

Article 1 (purpose)

The purpose of this Act is to regulate the production, storage, sale, transportation and other matters related to the handling of high pressure gases, their consumption as well as the manufacture and handling of their containers and to encourage voluntary activities by private businesses and the High Pressure Gas Safety Institute of Japan for the safety of high pressure gases with the aim of securing public safety by preventing accidents and disasters caused by high pressure gases.

Article 2 (definitions)

The term "high pressure gas" as used in this Act means any gas that falls under any of the following items:

(i) Compressed gas, the pressure (meaning gauge; the same shall apply hereinafter) of which is not less than 1 megapascal at its normal operating temperature and which is currently not less than 1 megapascal, or compressed gas, the pressure of which is not less than 1 megapascal at a temperature of 35 degrees Celsius (except compressed acetylene gas in both cases);

(ii) Compressed acetylene gas, the pressure of which is not less than 0.2 megapascal at its normal operating temperature and which is currently not less than 0.2 megapascal, or compressed acetylene gas, the pressure of which is not less than 0.2 megapascal at a temperature of 15 degrees Celsius;

(iii) Liquefied gas, the pressure of which is not less than 0.2 megapascal at its normal operating temperature and which is currently not less than 0.2 megapascal, or liquefied gas, the temperature of which is 35 degrees Celsius or less in the case that the pressure is 0.2 megapascal; or

(iv) In addition to what is listed in the preceding item, those liquefied gases, the pressure of which exceeds zero Pascal at a temperature of 35 degrees Celsius, and which, inclusive of liquefied hydrogen cyanide and liquefied methyl-bromide, are specified by a Cabinet Order.

Cabinet Order of High Pressure Gas Safety Act (cabinet order no. 20 of february 19, 1997)

Latest Amendments: Cabinet Order No. 328 of October 27, 2004

The Cabinet establishes this Order in accordance with the provisions of the High Pressure Gas Safety Act (act no. 204 of 1951) and for implementation thereof.

Article 7 (type of high pressure gas specified in cabinet order)

The types of gases, among those high pressure gases of Paragraph 1 of Article 24-2 of the Act, specifically specified in a Cabinet Order as requiring special care for the prevention of accidents in their consumption shall be the following gases in compressed and liquefied form:

(i) silane
(ii) phosphine
(iii) arsine
(iv) diborane
(v) hydrogen selenide
(vi) monogermane
(vii) disilene

Safety Regulations for General High Pressure Gas (ministry of international trade and industry ordinance no. 53 of may 25, 1966)

Latest Amendments: Ministry of Economy, Trade and Industry Ordinance No. 68 of September 29, 2015

Chapter I General Provisions

Article 1 (scope)

This is to set forth, based on the High Pressure Gas Safety Act (act no. 204 of 1951, hereinafter referred to as the "act"), the regulations on the safety (excluding the safety on the production of high pressure gases pertaining to the specific production businesses specified in the Safety Regulations for Industrial Complex, etc. (Ministry of International Trade and Industry Ordinance No. 88 of 1986)) on the high pressure gases (excluding high pressure gasses subject to the provisions of Regulations for Refrigeration Safety (ministry of international trade and industry ordinance no. 51 of 1966) and Safety Regulations for Liquefied Petroleum Gas (ministry of international trade and industry ordinance no. 52 of 1966): the same shall apply hereinafter).

Article 2 (definitions)

For the purpose of these regulations, the terms listed in the following items shall be defined as follows:

(i) "combustible gases" shall mean: acrylonitrile, acrolein, acetylene, acetaldehyde, arsine, ammonia, carbon monoxide, ethane, ethylamine, ethyl benzene, ethylene, ethyl chloride, vinyl chloride, chloromethyl, ethylene oxide, propylene oxide, hydrogen cyanide, cyclopropane, disilene, diborane, dimethylamine, hydrogen, hydrogen selenide, trimethylamine, carbon disulfide, butadiene, butane, butylene, propane, propylene, bromomethyl, benzene, phosphine, methane, monogermane, silane, monomethylamine, methyl ether, hydrogen sulfide and other gases falling under either of the following a. or b.
   a. The lower explosion limit (meaning the explosion limit when mixed with air: the same shall apply hereinafter) being 10% or less
   b. The difference between the upper limit and lower explosion limit being 20% or more

(ii) "toxic gases" shall mean: acrylonitrile, acrolein, sulfurous acid gas, arsine, ammonia, carbon monoxide, chlorine, chloromethyl, chloroprene, arsenic pentafluoride, phosphorus pentafluoride, ethylene oxide, nitrogen trifluoride, boron trifluoride, phosphorus trifluoride, hydrogen cyanide, diethylamine, disilene, sulfur tetrafluoride, silicon tetrafluoride, diborane, hydrogen selenide, trimethylamine, carbon disulfide, fluorine, bromomethyl, benzene, phosgene, phosphine, monogermane, silane, monomethylamine, hydrogen sulfide and other gases with threshold limit value being 200 ppm or less.

(iii) "special high pressure gases" shall mean: arsine, disilene, diborane, hydrogen selenide, phosphine, monogermane and silane.

(iv) "inert gases" shall mean: helium, neon, argon, krypton, xenon, radon, nitrogen, carbon dioxide or fluorocarbon (excluding combustible type).

Chapter II Permission, etc. concerning Production or Storage of High Pressure Gas

Section 1 Permission, etc. concerning Production of High Pressure Gas

Article 6 (technical standards concerning stationary production equipment)

Technical standards specified by an Ordinance of METI as referred to in Article 8, item (1) of the Act for the production facilities made up of stationary production equipment (excluding cold evaporator, compressed natural gas station, liquefied natural gas station and compressed hydrogen station) shall be as follows, provided, however, that this shall not apply in case of taking any safety measure which is approved by the Minister of Economy, Trade and Industry as having an equivalent effect, and refrigerating equipment for cooling of production equipment may be subject to the technical standards specified by the Regulations for Refrigeration Safety.

(xxvi) Electrical equipment concerning high pressure gas equipment for combustible gases (excluding ammonia and bromomethyl) shall be of a structure having explosion-proof capabilities suitable for its installation place and the type of the gas.

(xxxi) Production facilities of combustible gases or toxic gases specified by the Minister of Economy, Trade and Industry shall be installed with equipment to detect leak of such gases and trigger an alarm at places where gases leaked from such production facilities may accumulate.

(xxxvi) Piping concerning gas equipment for special high-pressure gas, arsenic pentafluoride, etc., sulfurous acid gas, ammonia, chlorine, chloromethyl, ethylene oxide, hydrogen cyanide, phosgene or hydrogen sulfide shall, wherever necessary, of double tube construction depending on the type, properties and pressure of these gases as well as on the nearby situation of the piping (including the concentrated condition of type 1 safety properties and type 2 safety properties in the vicinity of the business where the piping is installed), and necessary measures shall be taken to detect the leakage of the gas from such double tube, provided, however, that this shall not apply if the piping is prevented from being damaged by installing in a sheath or other protective structure and measures are taken to prevent any leaked gas from spreading to the vicinity.

Chapter VIII Notification concerning Consumption of High Pressure Gas

Article 55 (technical standards concerning consumers of specific high pressure gas)

Technical standards specified by an Ordinance of METI as referred to in Paragraph 1 of Article 24-3 of the Act shall be as follows.

(xxiv) Piping concerning consumption equipment for special high-pressure gas, liquefied ammonia or liquefied chloride shall, wherever necessary, of double tube construction depending on the type, properties and pressure of these gases as well as on the nearby situation of the piping (including the concentrated condition of type 1 safety properties and type 2 safety properties in the vicinity of the business where the piping is installed), and necessary measures shall be taken to detect the leakage of the gas from such double tube, provided, however, that this shall not apply if the piping is prevented from being damaged by installing in a sheath or other protective structure and measures are taken to prevent any leaked gas from spreading to the vicinity.

(xxvi) Consumption facilities shall be installed with equipment to detect leak of such gases and trigger an alarm at places where gases leaked from such production facilities may accumulate.

Exemplified Standards concerning Safety Regulations for General High Pressure Gas (enacted on march 26, 2001, amended on december 26, 2012)

23. Gas leakage detection and alarm equipment and place of installation

Relevant provisions

> Article 6 paragraph 1 item (xxxi), Article 7 paragraph 1 item (i), Article 7-3 paragraph 1 item (vii), paragraph 2 item (xvi), Article 12 paragraph 1 item (i), Article 22, Article 55 paragraph 1 item (xxvi)

Equipment to detect and trigger an alarm of any leakage of combustible gases and toxic gases (acrylonitrile, sulfurous acid gas, arsine, ammonia, carbon monoxide, chlorine, ethylene oxide, disilene, diborane, hydrogen selenide, carbon disulfide, benzene, phosphine, monogermane, silane and hydrogen sulfide) at production facilities, storage places and consumption facilities shall be in accordance with the following standards.

1. Function

Gas leakage detection and alarm equipment (hereinafter referred to as "Detection alarm

Related Laws and Regulations (JAPAN)

equipment" in 23 of these standards) shall be capable of detecting leakage of combustible gases or oxygen or toxic gases, indicating its concentration as well as triggering an alarm and shall have the following capabilities.

1.1 Detection alarm equipment shall be of catalytic combustion method, membrane type galvanic cell method, semi-conductor method or any other method to automatically trigger an alarm at the preset gas concentration (hereinafter referred to as "alarm setpoint") by detecting the change of detection element by an electrical mechanism.

1.2 Alarm setpoint shall be a quarter or less of a lower explosive limit for combustible gases, 25% for oxygen and acceptable concentration (twice the value of acceptable concentration for ammonia, chlorine and other toxic gases similar thereto with difficulty to prepare the calibration gas; the same shall apply to 1.6) or less for toxic gases, provided, however, that it shall be 0.1% or less for the Detection alarm equipment to be installed pursuant to 3.1 (6) c. In this case, Alarm setpoint shall be able to be set at any value.

1.3 The gas alarm accuracy of Detection alarm equipment shall be ±25% or less for combustible gases, ±5% or less for oxygen and ±30% or less for toxic gases of the Alarm setpoint.

1.4 The delay time for the Detection alarm equipment to trigger an alarm shall be inspected by applying the alarm delay test under the provision 6.7.2 of JIS M7626 (1994) correspondingly. This inspection shall be conducted by introducing the gas 1.6 times of the concentration of the Alarm setpoint and the delay then shall be within 30 seconds, provided, however, that it shall be within 1 minute for specific gases which delay more than that for the structure of the Detection alarm equipment or for theoretical reasons (ammonia, carbon monoxide or any other gases equivalent thereto).

1.5 Alarm accuracy shall not deteriorate even when there are ±10% fluctuations of power voltage, etc.

1.6 The scale of indicator shall, within each scale range, clearly indicate 0 to lower explosive limit (for those with the Alarm setpoint being low concentration, proper value of the lower explosive limit or less can be set in consideration of such Alarm setpoint), 0 to 50% for oxygen and 0 to 3 times the value of acceptable concentration for toxic gases.

1.7 Once an alarm is triggered, the alarm shall, in principle, continue even upon the change of gas concentration in the atmosphere and shall stop only by its inspection or measures to be taken.

1.8 Detection alarm equipment shall be regularly maintained in accordance with maintenance particulars described in instruction manuals or specifications. The results of maintenance shall also be recorded and retained for 3 years or more.

1.9 Calibration of the reading of gas leakage detection alarm equipment for special high-pressure gas shall be carried out at least once every 6 months.

1.10 Detection alarm equipment shall be checked at least once a month for triggering of an alarm upon the alarm circuit inspection and at least once a year for the proper operation by the detection and alarm inspection.

2. Construction

The construction of Detection alarm equipment shall be as follows.

2.1 It shall have sufficient strength (element and transmission circuit being particularly durable) and shall be easy to handle and maintain (particularly for the replacement of element, etc.)

2.2 The parts which come into contact with gases shall be made of corrosion-resistant materials or materials with sufficient anticorrosion treatment and other parts shall be finished with good coating or plating.

2.3 For explosion proof property, it shall have passed the test under Article 44 of Industrial Safety and Health Act (act no. 57 of 1972).

2.4 In the case of receiving alarms from 2 or more probes, receiving circuit shall be able to trigger an alarm if it is under the condition to activate the Detection alarm equipment and such point shall be identifiable even when the other triggers an alarm and activate the circuit.

2.5 Receiving circuit shall be made easily identifiable of it being activated.

2.6 Alarm shall trigger an alarm simultaneously with turning on or blinking of a lamp.

3. Installation place

Detection alarm equipment shall be installed as follows.

3.1 Installation place and quantity of probes of Detection alarm equipment in the production facilities (excluding piping: the same shall apply hereinafter in 3.1) shall be in accordance with the following items:

(1) In the circumference of a place where there are indoor-installed compressor, pump, reaction equipment, storage tank and other high-pressure gas equipment with high potential for gas leakage (excluding those specified in (3)) and where leaked gas is likely to accumulate: 1 or more per 10 meter circumference of these equipment group;

(2) If those high-pressure gas equipment as referred to in (1) are installed outdoor and are close to other high-pressure equipment, walls or other structures, or are installed inside a pit or the like, a place where leaked gas is likely to accumulate: 1 or more per 20 meter circumference of these equipment group;

(3) A place where leaked gas is likely to be accumulated in the circumference of production facilities including fire source such as a heating furnace: The number calculated by the ratio of 1 or more per 20 meter circumference of the place;

(4) Inside an instrument room (excluding the case where measure(note) is taken to prevent penetration of leaked gas): 1 or more;

(5) In the circumference of a group of filling ports of toxic gases: 1 or more;

(note) In principle, the measure to prevent penetration of leaked gas shall mean either of the following:

a. To retain the pressure inside the instrument room necessary for preventing penetration of gases from outside; or

b. To raise the entrance floor to at least 2.5 meters over the ground for the instrument room only for gases heavier than air.

(6) Notwithstanding the foregoing (1) to (5), the following standards shall apply to specific compressed hydrogen stations of Article 7-3, Paragraph 2:

a. 1 or more inside a steel casing or inside a fireproof room in which compressor is installed, provided, however, that for such fireproof room of which inside wall dimension exceeds 10 meters, the quantity shall be 1 or more for every 10 meters in such length;

b. 1 or more inside the dispenser case;

c. 1 each or more of Detection alarm equipment having 1 or more probes near the connection part such as the coupling between the filling hose and the container fixed onto a vehicle (see fig.1);

d. 1 or more on the upper piping module of accumulator (see fig.2);

e. 1 or more at a place where hydrogen is accumulated near the device to generate hydrogen such as a reformer.

3.2 Installation place and quantity of probes for Detection alarm equipment in a repository or consumption facilities (excluding piping; the same shall apply hereinafter in 3.2) shall be in accordance with the following items:

(1) In the circumference of a place where there are indoor-installed decompression equipment, storage equipment, consumption equipment (excluding part of burners, etc. which are equipped with an interlocking mechanism of pilot burner method and not likely to cause gas leakage) and other equipment with high potential for gas leakage and where leaked gas is likely to accumulate: 1 or more per 10 meters of the circumference of these equipment group;

(2) If those equipment as referred to in (1) are installed outdoor and are close to other equipment, walls or other structures, or are installed inside a pit or the like, a place where leaked gas is likely to accumulate: 1 or more per 20 meter circumference of these equipment group;

(3) If containers for special high-pressure gas, etc. are stored at a container depot: 1 or more in the circumference of a place of the container group where leaked gas is likely to accumulate;

(4) Inside a cylinder cabinet: 1 or more.

3.3 The height for the probe to be installed for the facilities of 3.1 or 3.2 shall be determined in accordance with conditions such as specific gravity of the gas, environment, height of gas equipment and so on.

3.4 A place where alarm is triggered and lamp is turned on or blinks shall be where parties concerned are stationed and is suitable for taking various countermeasures upon an alarm.

3.5 In cases where forced exhaust equipment is operated around the clock in production or consumption facilities, the provisions of 3.1 and (1), (2), (3) of 3.2 shall not apply and a probe shall be installed for every inlet of forced exhaust equipment.

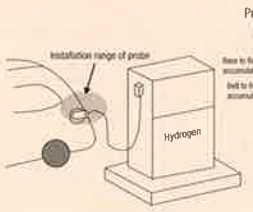


Fig.1 Example of Installation near the Connection like a Coupling

Fig.2 Example of Installation at Piping Module of Accumulators, etc.

27. Double tube for toxic gas piping

Relevant provisions
Article 6 paragraph 1 item (xxxvi), Article 12 paragraph 1 item (i), Article 22, Article 55 paragraph 1 item (xxiv)

With regard to double tube construction for gas equipment piping of special high-pressure gas, arsenic pentafluoride, etc., sulfurous acid gas, ammonia, chlorine, chloromethyl, ethylene oxide, hydrogen cyanide, phosgene and hydrogen sulfide, the following items shall apply:

1. Outer tube of the double tube construction shall have the standard inside diameter of 1.2 times or more of the outside diameter of the inner tube and material, wall thickness, etc. shall conform to the specifications under 7. Breakdown test and airtightness test, 8. Strength of high-pressure gas equipment and conduit, and 9. Standards of materials used for gas equipment, etc.

2. Any of the following measures shall be taken between the inside tube and outside tube of the double tube to detect leakage of gases:

2.1 To install a probe of gas leakage detection and alarm equipment between the inside tube and outside tube of the double tube;

2.2 To install a device to detect and alarm the rise of pressure between the inside tube and outside tube of the double tube;

2.3 To run inert gas such as nitrogen all the time between the inside tube and outside tube of the double tube, and to install a probe of gas leakage detection alarm equipment on its outlet; or

2.4 To suction between the inside tube and outside tube of the double tube all the time by exhaust equipment, etc. and to install a probe of gas leakage detection alarm equipment on its outlet.

Industrial Safety and Health Act (act no. 57 of june 8, 1972)

Latest Amendments: Act No. 17 of May 7, 2015

Chapter I General Provisions

Article 1 (purpose)

The purpose of this Act is to secure, in conjunction with the Labor Standards Act (Act No. 49 of 1947), the safety and health of workers in workplaces, as well as to facilitate the establishment of comfortable working environment, by promoting comprehensive and systematic countermeasures concerning the prevention of industrial accidents, such as taking measures for the establishment of standards for hazard prevention, clarifying the safety and health management responsibility and the promotion of voluntary activities with a view to preventing industrial accidents

Chapter IV Measures for Preventing the Dangers or Health Impairment of Workers

Article 20 (measures to be taken by employers, etc.)

The employer shall take necessary measures for preventing the following dangers:

Related Laws and Regulations (JAPAN)

(i) Dangers due to machines, instruments and other equipment (hereinafter referred to as "machines, etc.")
(ii) Dangers due to substances of an explosive nature, substances of a combustible nature and substances of an combustible nature
(iii) Dangers due to electricity, heat and other energy

Chapter V Regulations concerning Machines, etc. and Harmful Substances
Section 1 Regulations concerning Machines

Article 42 (restrictions on transfer, etc.)
Among machines, etc., other than specified machines, etc., which are listed in Appended Table 2, or require dangerous or harmful operations, or are used in a dangerous place, or used for preventing danger or health impairment, those defined by Cabinet Order shall not be transferred, leased or installed unless they conform to the construction code provided for by the Minister of Health, Labour and Welfare or are equipped with safety apparatus designated by the Minister of Health, Labour and Welfare.

Article 44-2 (type examination)
Of the machines, etc. as referred to in Article 42, 1 who has manufactured or imported a machine which is listed in Appended Table 4 and designated by the Cabinet Order shall have such manufactured or imported machine undergo the type examination to be conducted by the party registered by the Minister of Health, Labour and Welfare (hereinafter referred to as the "registered type examination agency") as prescribed by the Ordinance of the Ministry of Health, Labour and Welfare. However this provision shall not apply to the machines, etc., which have been imported, and which have undergone the examination set forth in the next paragraph.

Ordinance on Industrial Safety and Health (ministry of labour ordinance no. 32 of september 30, 1972)

Latest Amendments: Ministry of Health, Labour and Welfare Ordinance No. 175 of December 28, 2015

Part II Safety Standards

Chapter VI Prevention of Dangers in Excavating Work, etc.

Section 2 Construction Work of Tunnels, etc.

Subsection 1 Investigation, etc.

Article 382-2 (measurement, etc. of the concentration of combustible gas)
The employer shall, in the case of a construction work of tunnels, etc., the combustible gases are liable to be generated, designate a person charged with the measurement of the concentration of the combustible gases in order to prevent an explosion or fire and have the said person measure and record the concentration of the combustible gas at the places where the said combustible gases are liable to be generated or stagnate, every day before commencing the work for the day, after an earthquake of medium shock or heavier or when having found any abnormalities related to the said combustible gases.

Article 382-3 (installation, etc. of automatic alarms)
The employer shall, when it is found as a result of the measurement set forth in the preceding Article that the combustible gases exist and is liable to cause an explosion or fire, install automatic alarms at necessary places for an early detection of abnormal rise in the concentration of the combustible gases. In this case, the said automatic alarms shall have system, which is able to quickly alert workers who are working around the area of the detector of the automatic alarms to the abnormal rises in the concentration of the said combustible gas.
2. The employer shall, as regards the automatic alarm device set forth in the preceding paragraph, check the following matters before commencing the work for the day, and immediately repair when having found any abnormalities:
(i) Abnormalities in the measuring gauges
(ii) Abnormalities in detector
(iii) Function of the alarms

Subsection 1-3 Prevention of Explosions, Fires, etc.

Article 389-2 (measures in the case of automatic alarms sound)
The employer shall establish measures in advance that the workers concerned should take to prevent an explosion or fire due to combustible gas when the automatic alarms set forth in Article 382-3 sound, and make the said measures known to the said workers.

Part III Health Standards

Chapter I Harmful Working Environment

Article 583 (standards of concentration of carbon dioxide gas in a pit)
The employer shall ensure that the concentration of carbonic dioxide gas in the air is kept at 1.5% or less in workshop in pits. However, this shall not apply to lifesaving or danger prevention work using air respirators, oxygen respirators or hose masks.

Article 589 (workplace to be measured for work environment)
The workshops in pits prescribed by the Ordinance of the Ministry of Health, Labour and Welfare set forth in item (iv) of Article 21 of the Order shall be as follows:
(i) Workshops in pits where carbon dioxide gas stagnates or is liable to stagnate;
(ii) Workplace in a pit where temperature exceeds or is likely to exceed 28°C;
(iii) Workshops in pits provided with ventilation facilities.

Article 592 (measurement, etc., of concentration of carbon dioxide gas in a pit)
The employer shall, as regards a workshop in pit set forth in item (i) of Article 589, measure concentration of carbon dioxide gas, periodically once every period within a month.
2. The provisions of paragraph (2) of Article 590 shall apply mutatis mutandis to the case that measurements pursuant to the provision of the preceding paragraph have been carried out.

Ordinance on Prevention of Anoxia, etc. (ministry of labour ordinance no. 42 of september 30, 1972)

Latest Amendments: Ministry of Health, Labour and Welfare Ordinance No. 175 of December 19, 2003

In accordance with the provisions of Industrial Safety and Health Act (act no. 57 of 1972) and for the purpose of implementing the Act, ordinance on prevention of anoxia, etc. shall be set forth as follows:

Chapter I General Provisions

Article 1 (duties of the employer)
The employer shall make efforts to establish working methods, maintain a proper working environment and take measures necessary for preventing anoxia, etc.

Article 2 (definitions)
In this ordinance, the meanings of the terms are as defined respectively in the following items:
(i) Oxygen deficiency: States under which the oxygen concentration in the air is less than 18%.
(ii) Oxygen deficiency, etc.: The state defined in the preceding item or the state in which the concentration of hydrogen sulfide in the air is 10ppm or more.
(iii) Anoxia: The symptom observed in 1 who has inhaled oxygen-deficient air.
(iv) Hydrogen sulfide poisoning: The symptom observed in 1 who has inhaled the air in which the concentration of hydrogen sulfide is 10 ppm or more.
(v) Anoxia, etc.: Anoxia or hydrogen sulfide poisoning.
(vi) Hazardous work of oxygen deficiency: Those jobs to be carried out in places with the hazard of oxygen deficiency (hereinafter referred to as "oxygen-deficient place") designated in Attached Table 6 of the Enforcement Order (hereinafter referred to as "Cabinet Order") of the Industrial Safety and Health Law (cabinet ordinance no. 318 of 1972).
(vii) Class-1 hazardous work of oxygen deficiency: The oxygen deficiency-hazard work other than class-2 hazardous work of oxygen deficiency out of the oxygen-deficiency-hazard works.
(viii) Class-2 hazardous work of oxygen deficiency work: The work to be carried out in the oxygen-deficiency-hazard place designated in item 3-3, item 9 or item 12 of Attached Table 6 of the Cabinet Order (to be restricted to the places designated by the Minister of Health, Labour and Welfare as the places with the hazard of anoxia and hydrogen sulfide poisoning for the places designated in the said items) from among the oxygen-deficiency-hazard places.

Chapter II General Preventive Measures

Article 3 (working environment measurement, etc.)
For the workplace designated in item 9 of Article 21 of Cabinet Order, the employer shall measure the concentration of the oxygen in the air before having the workers start the day's work, providing that the concentrations of both the oxygen and hydrogen sulfide shall be measured for workplaces where class-2 hazardous work of oxygen deficiency is to be carried out.
2. When the employer has made the measurements of the oxygen concentrations in the air provided for by the preceding paragraph, he shall make a record of the items given below, every time the said measurements have been made, and shall keep the recorded results of the said measurements in custody for a period of 3 years.
(i) Date and time of the measurements
(ii) Method of measurement
(iii) Places at which the said measurements were carried out
(iv) Conditions of measurements
(v) Results of the measurements
(vi) Name of the measurer
(vii) Outline of the measures taken for prevention of anoxia based on the results of the measurements

Article 4 (measuring instruments)
When the employer has workers engage in hazardous work of oxygen-deficiency, he shall provide the instruments necessary for measurement of oxygen concentration in the air stipulated in Paragraph 1 of the preceding Article, or shall take measures for enabling the workers to easily make use of said instruments.

Article 5 (ventilation)
The employer whose workers engage in hazardous work of oxygen deficiency shall keep the concentration of oxygen in the air at least at 18% or more in the workplace (the concentration of the oxygen shall be 18% or more, and the concentration of the hydrogen sulfide, less than 10 ppm in the case of class-2 hazardous work of oxygen deficiency) by installing an appropriate ventilating system except in cases where a ventilating system cannot be installed in order to prevent explosion or oxidization, etc., and where it is extremely difficult to install a ventilating system due to the nature of the work to be carried out.
2. The employer shall not be allowed to use pure oxygen while the workplace is ventilated conforming to the provision of the preceding paragraph.

Other Relevant Laws and Regulations

In addition to the foregoing laws and regulations, there are following relevant laws and regulations:

- Working Environment Measurement Act
- Fire Service Act
- Ship Safety Act
- Act on Maintenance of Sanitation in Buildings (building maintenance act)
- Act on Securing of Safety and Optimization of Transaction of Liquefied Petroleum Gas (liquefied petroleum gas act)
- Gas Business Act
- Act on Hot Springs

Explosion-proof Construction

Explosion-proof electrical equipment are currently classified based on 2 types of standards.
1 is Constructional Requirements for Electrical Equipment for Explosive Atmospheres of the Ministry of Labour Notification No. 16 of 1969 and another is its partial amendment, Recommended Practices for Explosion-Protected Electrical Installations in General Industries as referred to in the Ministry of Health, Labour and Welfare, Labour Standards Bureau Chief Notification No. 2 of August 24, 2010 issued by Labour Standards Bureau (JAPAN).

【Constructional Requirements for Electrical Equipment for Explosive Atmospheres】

Types of Explosion-proof Construction of Electrical Equipment for Explosive Atmospheres and their Corresponding Symbols

Kind of type of gas-explosion protection	Symbol
Intrinsic safety	ia or ib
Flameproof enclosures	d
Pressurized enclosures	f
Increased safety	e
Oil-immersion	o
Type of protection 'n'	nA, nC, nR or nL
Encapsulation	ma or mb
Special	s

Explosion Class Classification of Combustible Gases or Vapors

Explosion class	Limit of flame propagation (mm)
1	Over 0.6
2	Over 0.4 and less than 0.6
3 (a,b,c,n) ※1	Equal to or less than 0.4

※1 3a, 3b, 3c and 3n in the explosion class denote hydrogen and water gas, carbon disulfide, acetylene and all gases and vapors, respectively.

Ignition Point Classification of Combustible Gases or Vapors

Ignition point	Ignition point (°C)	Permissible temperature of electrical equipment (°C)
G1	Over 450	360
G2	Over 300 and less than 450	240
G3	Over 200 and less than 300	160
G4	Over 135 and less than 200	110
G5	Over 100 and less than 135	80

Ignition points of representative explosive gas classes under the Constructional Requirements for Electrical Equipment for Explosive Atmospheres

Temperature class / Explosion-proof class	G1	G2	G3	G4	G5
1	Acetone Ammonia Carbon monoxide Ethane Acetic acid Ethyl acetate Toluene Propane Benzene Methanol Methane	Ethanol Isopentyl acetate Butane	Gasoline Hexane	Acetaldehyde	
2		Ethylene Ethylene oxide			
3	Water gas Hydrogen	Acetylene			

【Recommended Practices for Explosion-Protected Electrical Installations in General Industries】

Types of Explosion-proof Construction of Electrical Equipment for Explosive Atmospheres and their Corresponding Symbols※2

Kind of type of gas-explosion protection	Symbol
Intrinsic safety	ia or ib
Flameproof enclosures	d
Pressurized enclosures	px or py
Increased safety	e
Oil-immersion	o
Type of protection 'n'	nA, nC, nR or nL
Encapsulation	ma or mb
Special	s

※2 To indicate the explosion-proof construction under the Recommended Practices for Explosion-Protected Electrical Installations in General Industries, "Ex" needs to be added in front of each explosion-proof class symbol.

Classification of Explosion-proof Electrical Equipment Corresponding to the Maximum Experimental Safe Gap※3

Electrical equipment group of flameproof enclosure	Maximum experimental safe gap (mm)
ⅡA	Equal to or more than 0.9
ⅡB	Over 0.5 and less than 0.9
ⅡC	Equal to or less than 0.5

Classification of Explosion-proof Electrical Equipment Corresponding to the Minimum Ignition Current※3

Electrical equipment group of intrinsic safety	Minimum ignition current ratio (methane = 1)
ⅡA	Over 0.8
ⅡB	Equal to or more than 0.45 and equal to or less than 0.8
ⅡC	Less than 0.45

※3 Electrical equipment groups are classified into IIA, IIB and IIC but classification may differ depending on the type of explosion-proof construction.

Classification of Combustible Gases or Vapors Corresponding to the Temperature Class of Electrical Equipment

Maximum surface temperature of electrical equipment (°C)	Temperature class	Ignition temperatures of combustible gases or vapors (°C)
Less than 450	T1	Over 450
Equal to or less than 300	T2	Over 300 and less than 450
Equal to or less than 200	T3	Over 200 and less than 300
Equal to or less than 135	T4	Over 135 and less than 200
Equal to or less than 100	T5	Over 100 and less than 135
Equal to or less than 85	T6	Over 85 and less than 100

Temperature Classes of Representative Explosive Gases under the Recommended Practices for Explosion-Protected Electrical Installations in General Industries

Temperature class / Explosion-proof class	T1	T2	T3	T4	T5	T6
ⅡA	Acetone Ammonia Isobutane Ethane Acetic acid Ethyl acetate Toluene Benzene Methane	Isopentyl acetate Acetic anhydride Butane Propane Methanol	Hexane	Acetaldehyde		
ⅡB	Carbon monoxide	Ethanol Ethylene Ethylene oxide				
ⅡC	Water gas Hydrogen	Acetylene				Carbon disulfide

Explosion-proof Class of Model GX-2012

Explosion-proof class: Exia II CT4X

Ex: Symbol to indicate explosion-proof construction under the Recommended Practices for Explosion-Protected Electrical Installations in General Industries

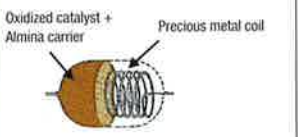
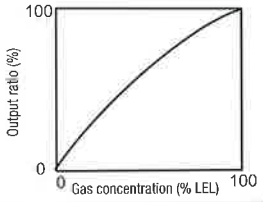
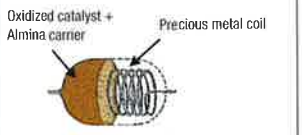
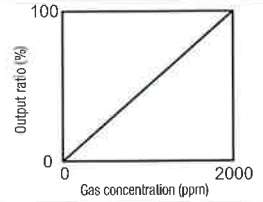
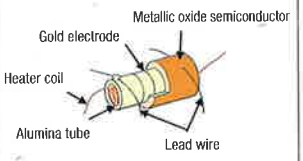
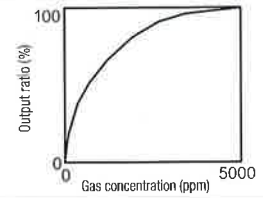
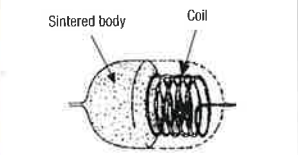
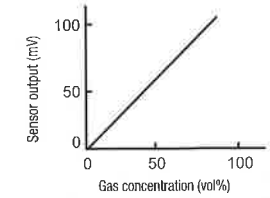
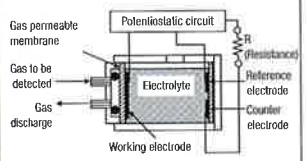
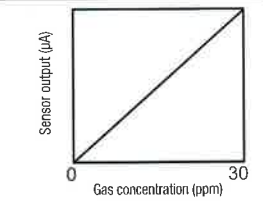
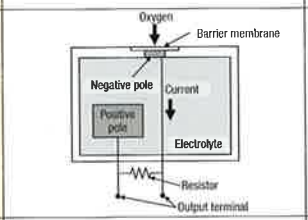
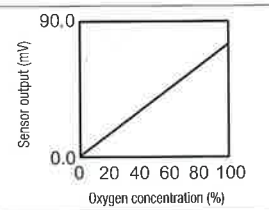
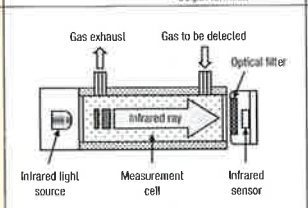
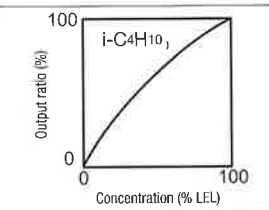
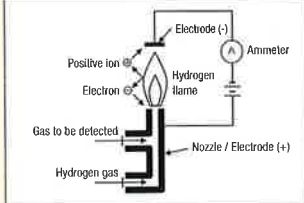
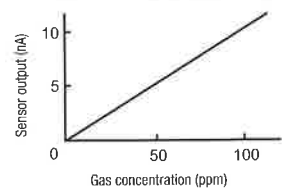
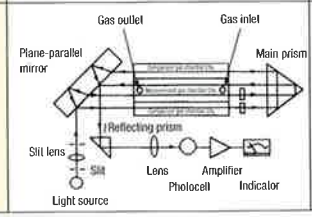
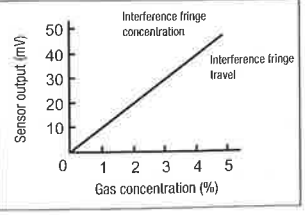
ia: Intrinsic safety

IIC: Minimum ignition current ratio (methane = 1) less than 0.45

T4: Ignition temperature of combustible gases or vapors over 135°C and less than 200°C

X: Symbol to indicate separate precautionary statement

List of Detection Principles

	Principle and advantage	Construction	Output characteristics
Catalytic Combustion HW	This method uses calorific power generated by combustible gases burning on oxidation catalyst (resistance variation of precious metal coil). ● The sensor output is almost proportional (linear) to the concentration of gas up to the lower explosive limit. ● There is almost no effect from the temperature and humidity of usage environment. ● Good response with speedy reaction and excellent in accuracy and reproducibility.		
New Ceramic NC	This method uses calorific power generated by combustible gases burning on the originally developed super-atomization oxidative catalyst (new ceramics). ● A single sensor can detect a wide range of concentrations from ppm to % LEL. ● There is almost no effect from the temperature and humidity of usage environment. ● Compared to the conventional catalytic combustion method sensor, it has excellent poisoning resistance, less sensitivity deterioration and prolonged stability.		
Semiconductor SG	This method uses resistance variations that occur when metallic oxide semiconductor cotacts gases. ● It has high sensor output in the low concentration range and has high sensitivity. ● It can detect not only combustible gases but also various gases including toxic gas. ● While controlling the sensitivity for miscellaneous gases, methane or isobutene can be detected selectively. ● Compared to other methods, this method has large tolerance under the harsh environmental conditions.		
Thermal Conductivity TE	This method uses the difference in thermal conduction unique to gases when they contact heated element. ● Up to 100 vol% gas concentration, the output is almost proportional (linear) to the concentration. ● Without chemical reaction such as a combustion reaction, no deterioration or poisoning of catalyst ensures long and stable use. ● With compensation element, it is almost free from the effect of the ambient environment. ● Nonflammable gases such as high-concentration argon, nitrogen and carbon dioxide can be detected.		
Electrochemical ES	Gas is subject to electrolysis on electrodes kept at constant potential and the current generated then is detected as gas concentration. ● Toxic gas can be detected with high sensitivity (e.g. arsine 0 to 0.2 ppm). ● By choosing bias voltage, gas to be detected can be detected selectively. ● Linear output enables accurate measurement of low-concentration gases.		
Galvanic cell OS	The current generated upon the electrolysis of oxygen on electrodes is detected as oxygen concentration. ● Product can be made smaller and lighter. ● No external power supply is needed for sensor operation. ● Output up to 100 vol% is proportional to oxygen concentration. ● Temperature compensation by a thermistor built in a sensor makes the temperature dependence of reading virtually nonexistent.		
Non-dispersive Infrared DE	This method uses the absorbed amount by gas of infrared rays radiated from the light source in the sensor. ● It provides accurate and stable measurement. ● Less sensitivity deterioration ensures stable measurement results for a long time. ● It has less influence from coexisting gas, water vapor and the like and is excellent in selectivity. ● As oxygen concentration has no effect, measurement is possible even in inert gas or N2.		
Flame ionization FID	This method uses the changes in current value by ionization of carbon hydride and other gases in hydrogen flame. ● It features quick response and high sensitivity. ● Output is almost proportional to the number of carbon in carbon hydride and will not be affected by inorganic carbon compound at all. ● Output shows high linearity within the measurement range of concentration.		
Optical interferometric FI	This method uses the nature of light being refracted by gas. ● Without using any chemical reaction, it has no deterioration in sensitivity and is excellent in prolonged stability. ● Continuous measurement of gas concentration can be conducted with accuracy for various processes. ● Measurement is possible in the order from 1000 ppm to 100 vol%.		

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C9E-0030-170220 (S)