



Calibration gas generation system Permeater

PD-1C/PD-1C-2



PD-1C

NEW! PD-1C-2

The Permeater is a gas generator for calibration purposes that utilises permeation and diffusion tubes to generate the calibration gas. When the permeation and diffusion tubes are set at a constant temperature, the weight of both the permeating and the evaporating diffusion gas will be respectively set at constant levels. In this manner, calibration gas is continuously generated by setting both tubes at a constant temperature and providing a constant flow of dilution gas such as air or nitrogen.

Calibration gas generation system Permeater

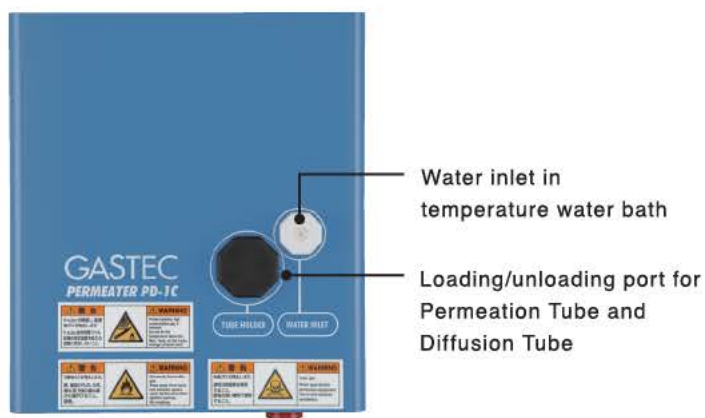
- Gas for calibration can be generated continuously for longer periods of time
- Calibration gas can be easily generated in a wide range of concentrations
- Highly reliable as concentration is determined by measuring basic physical quantities such as weight loss and dilution gas quantity
- Many types of low concentration calibration gases can be generated
- Automatic calculation of the dilution gas flow rate when the desired gas concentration to be generated is entered on the touch screen
- Mass flow controller (gas flow controller) controls flow changes

Single-Channel

PD-1C



Top view



Rear view



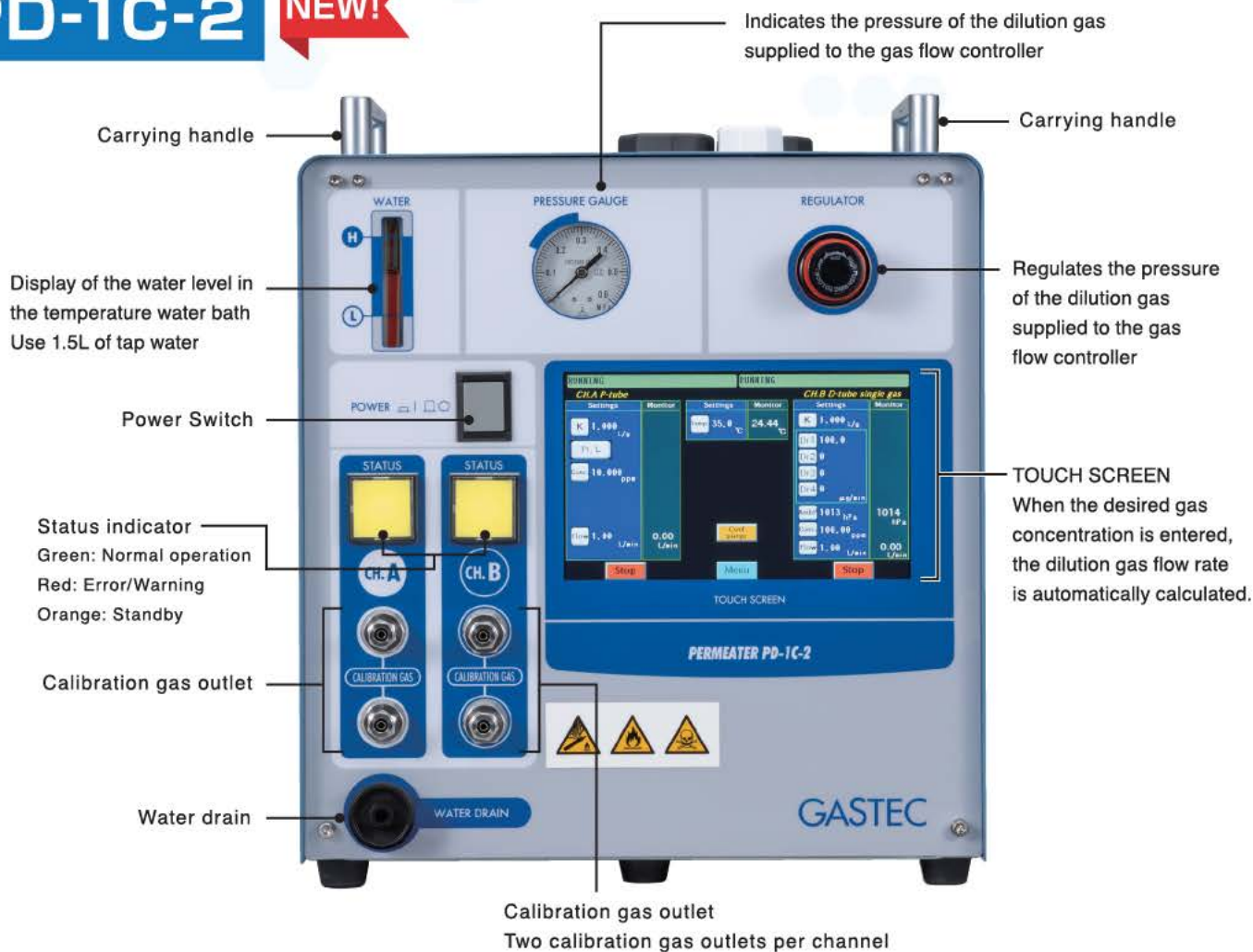
Examples of use

- Calibration gases for environmental measurement and analysis equipment
- Corrosion test
- Exposure test
- Filter evaluation test of air purifiers
- Evaluation tests on sensors and other components
- Odor test
- Deodorisation test

Dual-Channel

PD-1C-2

NEW!



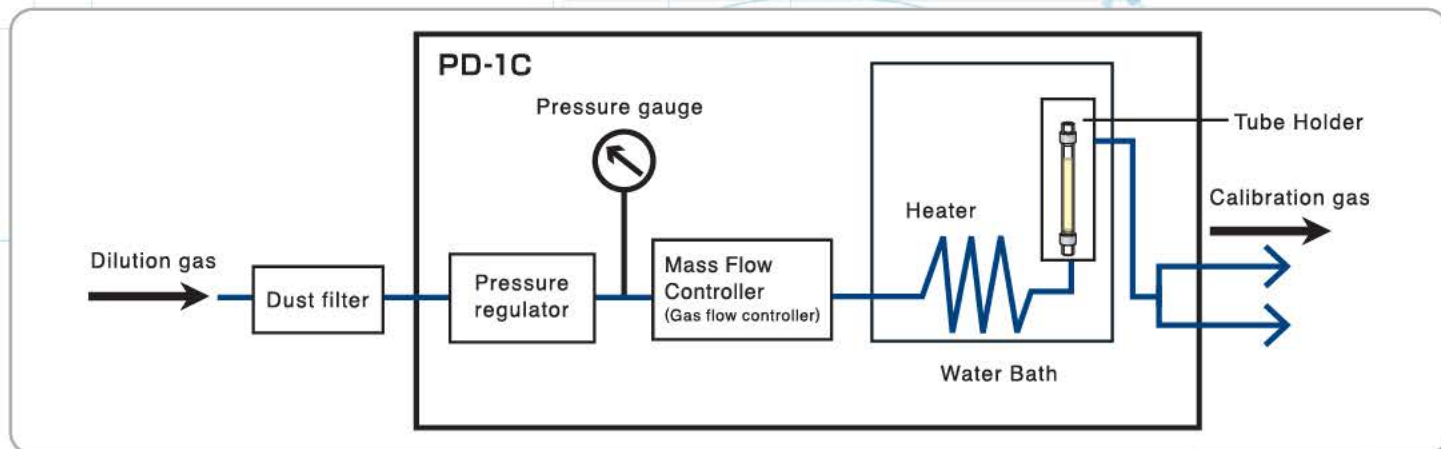
Top view



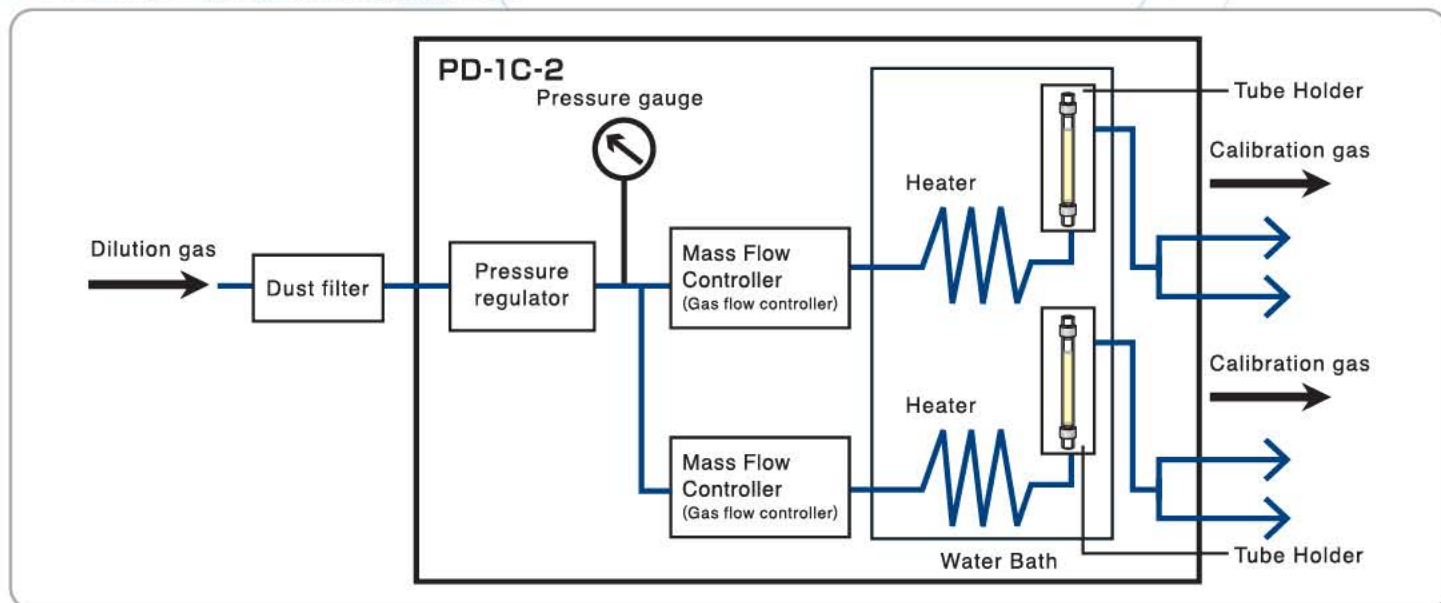
Rear view



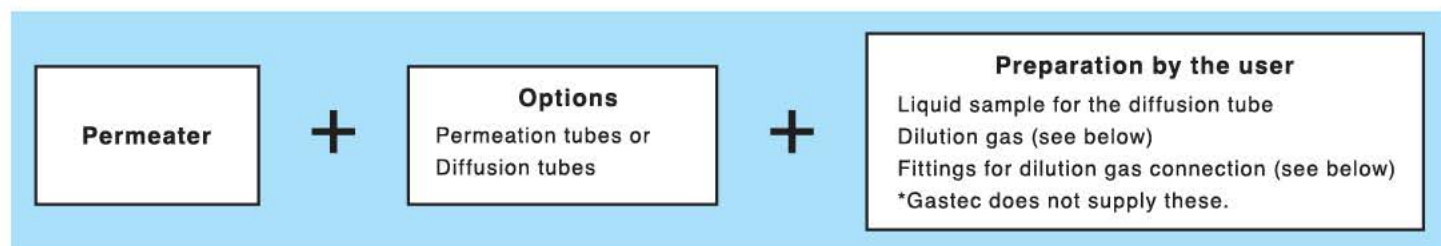
■ PD-1C flow path diagram



■ PD-1C-2 flow path diagram

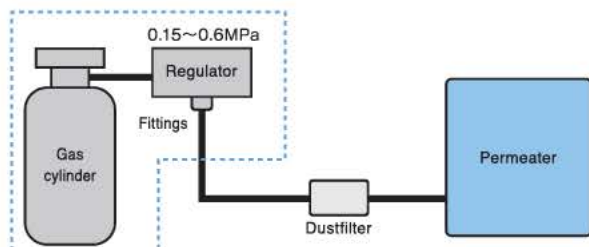


■ Preparation for use of permeator

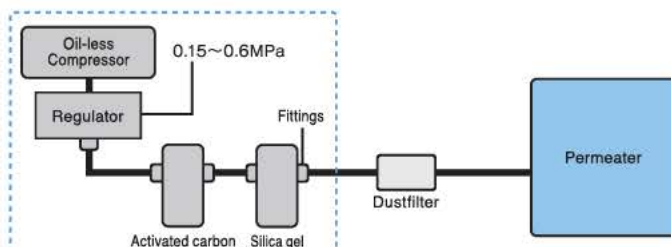


For the dilution gas

The dilution gas for Permeator is nitrogen or air in a high-pressure gas cylinder, or air compressed with an oil-less compressor, cleaned with activated carbon and silica gel. Use a regulator that can be pressurized from 0.15 to 0.6MPa and supplied to the Permeator.



Preparation by the user



Preparation by the user

* Use a cylinder which is capable of withstanding a pressure of 1.2 MPa or higher to fill activated carbon or silica gel.

*1 Room temperature 15-30 °C *2 Permeation tubes with H in Cat. No.
*3 The item(s) may vary by country or region.

*1 Room temperature 15-30 °C *2 Permeation tubes with H in Cat. No.
*3 The item(s) may vary by country or region.

Options



Permeation tube

*The tubes shown in the photo above are examples of permeation tubes.



Diffusion tube 3100

Suitable for continuous generation of single component gases for calibration over sustained periods of time.



Diffusion tube for multiple components 3200

Mixtures of up to four substances can be prepared simultaneously in one flow path.



Mixing/Splitting Unit (Three-Way) PD25

This unit can mix calibration gas prepared in two separate flow paths, and it can also split calibration gas from a single flow path.



Two-Way Mixer PD26

Promotes gas mixing when used in conjunction with the Mixing/Splitting Unit (Three-Way) PD25.



Sampling port PD27

Enables sampling a portion of the continuously flowing calibration gas.



Humidifier PD28

Humidifies dilution gas continuously. Recommended set flow rate: 1L/min or less



Diffusion Tube D-50

When used with the double deck diffusion tube holding cage PD23, highly concentrated calibration gases can be generated.



Diffusion Tube D-50-4

When used with the double deck diffusion tube holding cage PD23 or the triple deck diffusion tube holding cage PD24, highly concentrated calibration gases can be generated.



Double deck diffusion tube holding cage PD23

Holds two D-50 or D-50-4 diffusion tubes.



Triple deck diffusion tube holding cage PD24

Holds three D-50-4 diffusion tubes.

Generating calibration gas with a diffusion tube

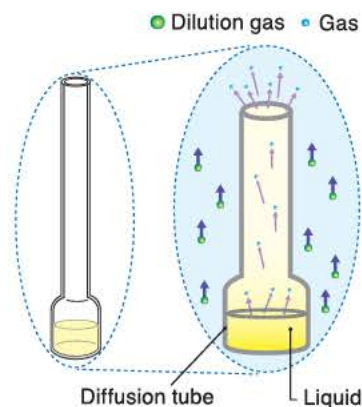
The diffusion tube method is used for the preparation of substances that are generally liquid*1 at room temperature, such as organic solvents.

A diffusion tube with a certain inner diameter is filled with a liquid preparation gas using a syringe, which is maintained at a constant temperature so that the evaporation and diffusion of the liquid in the tube is constant and a constant flow of dilution gas can be fed into it to continuously generate desired low concentration of the calibration gas.

The diffusion tube is a glass container consisting of a diffusion tube with a fixed inner diameter and a liquid reservoir. The diffusion rate is proportional to the cross-sectional area of the diffusion tube and inversely proportional to its length.

*1 Although not a common application, gases of substances that are solid at normal temperatures can be generated using gas diffusion tubes. Please contact your GASTEC representative for information regarding specific substances.

*2 This method cannot be applied to substances with extremely high or low vapour pressure or substances with decomposability, corrosiveness, hygroscopicity or polymerizability due to their diffusion rate not being constant.



■ Calculation of calibration gas concentration with diffusion tube

$$C = \frac{K \times Dr \times 10^3}{F}$$

C : Gas concentration for calibration gas (ppm)
Dr: Diffusion rate (μg/min)
F : Flow of dilution gas (mL/min)
K : Coefficient for converting the gas weight into volume (L/g)

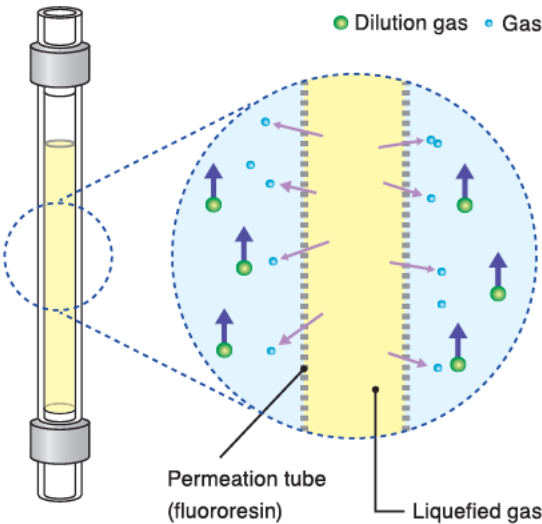
$$K = \frac{22.4}{M} \times \frac{273+t}{273} \times \frac{760}{P}$$

M=Molecular weight
t=Temperature
P=Pressure (mmHg)

For diffusion tube, use substances with a purity of approx. 95% or higher. Liquid samples must be prepared by the user.

Generating calibration gas with a permeation tube

A permeation tube is a fluororesin tube that contains high-grade liquefied gas. When the tube is exposed to a certain temperature, liquefied gas penetrates the tube wall by osmosis in time-increments enabling a specific quantity of gas to be retained in the tube. Consequently, a carrier gas flowing at a constant speed (for calibration purposes) can be continuously generated by keeping the tube at a fixed temperature and infusing a constant quantity of dilution gas. This method is highly reliable because the concentration of the calibration gas is determined by calculating the decrease in weight of the permeation tube and the quantity of dilution gas. This dynamic method also enables highly reactive gases such as hydrogen sulphide or ammonia to be generated. As shown in the table below, there are many different kinds of Permeation tubes and they are widely used because they can provide a stable supply of calibration gas.



■ Calculation of calibration gas concentration with permeation tube

$$C = \frac{K \times Pr \times L}{F}$$

C : Gas concentration for calibration gas (ppm)
Pr : Permeation rate (ng/min/cm)
L : Effective length of tube (cm)
F : Flow of dilution gas (mL/min)
K : Coefficient for converting the gas weight into volume (L/g)

$$K = \frac{22.4}{M} \times \frac{273+t}{273} \times \frac{760}{P}$$

M=Molecular weight
t=Temperature
P=Pressure (mmHg)

■ Calibration gas examples that can be generated by using a single permeation tube (with 200 to 10000mL/min dilution)

Calibration gas	Catalogue No.	Temperature (°C)	Permeation rate (typical values)	Concentration range (ppm)
Ammonia	P-3	25	117	0.2 - 8.3
		30	174	0.3 - 12.4
		35	250	0.4 - 17.9
Ammonia	P-3-M	25	182	0.3 - 13.0
		30	271	0.4 - 19.4
		35	390	0.6 - 28.0
Bromine	P-10-H	35	106	0.016 - 0.81
		50	330	0.050 - 2.52
1, 3-Butadiene	P-174-H	35	1400	0.7 - 31
Chlorine	P-8-5	25	897	0.15 - 7.7
		30	1300	0.22 - 11.2
		35	1906	0.33 - 16.4
Chlorine	P-8-M	25	1450	0.5 - 25.0
		30	2100	0.7 - 36.2
		35	3080	1.1 - 53.1
Dimethyl disulphide	P-73-H	35	11	0.003 - 0.14
		50	35	0.01 - 0.45
Dimethyl sulphide	P-74-H	35	111	0.04 - 2.1
		50	320	0.13 - 6.3
Ethyl mercaptan	P-72-H	35	95	0.04 - 1.87
Formaldehyde	P-91-H-5	50	12	0.0049 - 0.24
Hydrogen sulphide	P-4	25	160	0.1 - 5.7
		30	248	0.2 - 8.8
		35	380	0.3 - 13.6
Methyl chloride	P-132-H	30	3200	1.6 - 77

Calibration gas	Catalogue No.	Temperature (°C)	Permeation rate (typical values)	Concentration range (ppm)
Methyl mercaptan	P-71-5	30	25	0.007 - 0.31
		35	36	0.01 - 0.45
		50	120	0.03 - 1.52
Methyl mercaptan	P-71-H	30	305	0.16 - 7.7
Methylamine	P-182-H	35	450	0.23 - 11.4
		35	650	0.5 - 25.6
Methylene chloride	P-138-H	50	1100	0.3 - 15.8
Propane	P-100	30	45	0.03 - 1.25
		35	70	0.04 - 1.9
Propylene oxide	P-164-H	50	700	0.3 - 15
Styrene	P-124-H	35	19	0.0045 - 0.22
Sulphur dioxide	P-5-5	25	176	0.04 - 1.6
		30	265	0.05 - 2.5
		35	380	0.1 - 3.6
Sulphur dioxide	P-5	25	176	0.1 - 3.3
		30	265	0.1 - 5.0
		35	380	0.2 - 7.2
Sulphur dioxide	P-5-H	30	2788	1.1 - 53.2
		35	4000	1.6 - 76.4
Trimethylamine	P-180-H	35	150	0.06 - 3.1
Vinyl chloride	P-131	30	126	0.05 - 2.4
		35	190	0.08 - 3.7
Vinyl chloride	P-131-H	30	2000	0.8 - 39
		35	3000	1.2 - 58
Vinylidene chloride	P-130-H	35	650	0.16 - 8.2

- Calculate the concentration range based on the Pr shown for each permeation tube.
- If 10 (5 for permeation tubes with H in Cat. No.) permeation tubes are used 10 (5 for permeation tubes with H in Cat. No.) times the concentration shown in Table can be prepared.
- As Permeation tubes have individual differences in permeation rates, the above concentration ranges may differ slightly from the actual range that can be controlled.

■ Calibration gas examples that can be generated by using No.3100 diffusion tube (with 200 to 8000mL/min dilution at 30°C(86 °F))

Calibration gas	Diffusion tube type	Diffusion rate (μg/min)30°C	K value (25°C 1atm)	Concentration range(ppm)30°C
Acetic acid	D-30	37.8	0.407	2 - 77
	D-20	12.5		0.6 - 25
	D-10	5.8		0.3 - 12
Acetone	D-30	490	0.421	26 - 1030
	D-20	170		9 - 358
	D-10	75		4 - 158
Amyl acetate	D-30	19	0.188	0.45 - 18
	D-20	6.5		0.15 - 6
	D-10	2.7		0.06 - 2.5
Benzene	D-30	215	0.313	8.4 - 336
	D-20	75		2.9 - 117
	D-10	31		1.2 - 48.5
1-Butanol	D-30	15	0.33	0.62 - 25
	D-20	5.3		0.22 - 8.8
	D-10	2.4		0.1 - 4
2-Butanol	D-30	38	0.33	1.6 - 63
	D-20	13		0.54 - 21.5
	D-10	5.3		0.22 - 8.8
Butyl acetate	D-30	24	0.21	0.6 - 25
	D-20	8.8		0.23 - 9.2
	D-10	4.1		0.11 - 4.4
Carbon disulphide	D-30	1180	0.321	47 - 1890
	D-20	405		16 - 650
	D-10	170		6.8 - 270
Carbon tetrachloride	D-30	445	0.159	9 - 350
	D-20	155		3 - 120
	D-10	65		1.3 - 52
Chlorobenzene	D-30	32	0.217	0.9 - 35
	D-20	11		0.3 - 12
	D-10	4.6		0.125 - 5
Chloroform	D-30	675	0.205	17 - 690
	D-20	230		6 - 240
	D-10	100		2.5 - 100
Cyclohexanol	D-30	3.4	0.244	0.1 - 4
	D-20	1.2		0.04 - 1.5
	D-10	0.47		0.014 - 0.6
Cyclohexanone	D-30	9.8	0.249	0.3 - 12
	D-20	3.3		0.1 - 4
	D-10	1.4		0.044 - 1.7
o-Dichlorobenzene	D-30	4.8	0.166	0.1 - 4
	D-20	1.6		0.033 - 1.33
	D-10	0.7		0.015 - 0.6
cis-1,2-Dichloroethylene	D-30	598	0.252	18.8 - 753
	D-20	203		6.4 - 256
	D-10	79		2.5 - 99.5
trans-1,2-Dichloroethylene	D-30	1241	0.252	39.1 - 1564
	D-20	422		13.3 - 532
	D-10	165		5.2 - 208

Calibration gas	Diffusion tube type	Diffusion rate (μg/min)30°C	K value (25°C 1atm)	Concentration range(ppm)30°C
N,N-Dimethylformamide	D-30	8.5	0.335	0.36 - 14.2
	D-20	2.9		0.12 - 4.8
	D-10	1.3		0.05 - 2.1
1,4-Dioxane	D-30	89	0.277	3 - 120
	D-20	31		1.1 - 43
	D-10	13		0.45 - 18
Ethanol	D-30	104	0.531	7 - 277
	D-20	35.7		2 - 95
	D-10	15.5		1 - 41
Ethyl acetate	D-30	225	0.278	7.8 - 310
	D-20	78		2.7 - 108
	D-10	33		1.2 - 46
Ethylene dichloride	D-30	220	0.247	7 - 270
	D-20	75		2.3 - 93
	D-10	31		1 - 40
Ethyl ether	D-30	2210	0.33	91 - 3650
	D-20	770		32 - 1270
	D-10	340		14 - 560
n-Hexane	D-30	315	0.284	11.2 - 447
	D-20	110		3.9 - 156
	D-10	46		1.6 - 65
Isoamyl acetate	D-30	18	0.188	0.42 - 17
	D-20	6		0.14 - 5.6
	D-10	2.4		0.06 - 2.3
Isoamyl alcohol	D-30	8.6	0.277	0.3 - 12
	D-20	2.9		0.1 - 4
	D-10	1.2		0.04 - 1.7
Isobutyl acetate	D-30	48	0.21	1.3 - 50
	D-20	17		0.45 - 18
	D-10	6.8		0.18 - 7
Isobutyl alcohol	D-30	24	0.33	1 - 40
	D-20	8.5		0.35 - 14
	D-10	3.6		0.15 - 6
Isopropyl acetate	D-30	145	0.239	4.3 - 170
	D-20	50		1.5 - 60
	D-10	21		0.63 - 25
Isopropyl alcohol	D-30	85	0.407	4.3 - 170
	D-20	29		1.5 - 60
	D-10	13		0.66 - 27
Methanol	D-30	210	0.763	20 - 800
	D-20	72		6.9 - 275
	D-10	31		3 - 120
Methyl acetate	D-30	535	0.33	22 - 880
	D-20	185		7.6 - 305
	D-10	79		3.3 - 130
Methyl n-butyl ketone	D-30	31	0.244	0.95 - 37.8
	D-20	11		0.34 - 13.4
	D-10	4.3		0.13 - 5.3

Calibration gas	Diffusion tube type	Diffusion rate (μg/min)30°C	K value (25°C 1atm)	Concentration range(ppm)30°C
Methylcyclohexanol	D-30	2.4	0.214	0.06 - 2.6
	D-20	0.83		0.022 - 0.9
	D-10	0.33		0.009 - 0.35
Methylcyclohexanone	D-30	6.9	0.218	0.19 - 7.5
	D-20	2.4		0.065 - 2.6
	D-10	1		0.027 - 1.1
Methylene chloride	D-30	1600	0.288	58 - 2300
	D-20	545		20 - 790
	D-10	230		8.3 - 330
Methyl ethyl ketone	D-30	185	0.339	7.8 - 314
	D-20	64		2.7 - 109
	D-10	27		1.14 - 46
Methyl isobutyl ketone	D-30	44	0.244	1.3 - 54
	D-20	16		0.49 - 19.5
	D-10	7.4		0.23 - 9
n-Pentane	D-30	1688	0.339	72 - 2860
	D-20	589		25 - 998
	D-10	253		11 - 428
Propyl acetate	D-30	91	0.239	2.7 - 110
	D-20	31		0.93 - 37
	D-10	13		0.4 - 16
Styrene	D-30	15	0.235	0.44 - 17.6
	D-20	5.3		0.16 - 6
	D-10	2.3		0.07 - 2.7
1,1,2,2-Tetrachloroethane	D-30	18	0.146	0.33 - 13
	D-20	6.2		0.11 - 4.5
	D-10	2.6		0.05 - 1.9
Tetrachloroethylene	D-30	66	0.147	1.2 - 49
	D-20	23		0.4 - 17
	D-10	10		0.2 - 7.4
Tetrahydrofuran	D-30	345	0.339	15 - 585
	D-20	120		5 - 200
	D-10	53		2.3 - 90
Toluene	D-30	65	0.265	2.2 - 86
	D-20	23		0.76 - 30
	D-10	9.6		0.4 - 14
1,1,1-Trichloroethane	D-30	380	0.183	8.7 - 350
	D-20	130		3 - 120
	D-10	56		1.3 - 51
Trichloroethylene	D-30	245	0.186	5.7 - 228
	D-20	85		2 - 79
	D-10	36		0.6 - 34
Xylene	D-30	21	0.23	0.6 - 24
	D-20	7.3		0.2 - 8
	D-10	3.3		0.1 - 4

- The Dr values in the table are our measured or estimated values. For higher accuracy, we recommend actual measurement under actual conditions of use.
- If the diffusion tube is held at 50 °C, concentrations approximately three times higher than those shown in the table can be prepared. For further information, please contact us.

■ Calibration gas examples that can be generated by using No.3200 diffusion tube (with 200 to 8000mL/min dilution at 30 to 50°C(86 to 122°F))

Calibration gas	Calibration range(ppm)
Acetic acid	0.1 - 260
Acetone	1.5 - 4,600
Acrylonitrile	1.1 - 910
Amyl acetate	0.1 - 20
Aniline	0.1 - 9.1
Benzene	0.5 - 1,100
Benzotrichloride	0.02 - 0.7
1-Butanol	0.1 - 100
sec-Butanol	0.1 - 260
tert-Butanol	0.2 - 610
Butyl acetate	0.1 - 62
Carbon disulphide	2.7 - 4,600
Carbon tetrachloride	0.5 - 1,100
Chlorobenzene	0.1 - 110
Chloroform	1.0 - 2,600
Cyclohexane	0.8 - 550
Cyclohexanol	0.1 - 5.9
Cyclohexanone	0.1 - 25

Calibration gas	Calibration range(ppm)
o-Dichlorobenzene	0.1 - 8.5
1,1-Dichloroethane	1.3 - 3,700
1,2-Dichloroethylene	4.1 - 1,700
Diethylamine	1.5 - 4,600
N,N-Dimethylformamide	0.1 - 61
1,4-Dioxane	0.2 - 430
Ethanol	0.4 - 1,000
Ethyl acetate	0.5 - 1,100
Ethyl benzene	0.1 - 96
Ethyl bromide	4.1 - 3,400
Ethylene dichloride	0.4 - 900
Ethyl ether	5.3 - 4,300
Formic acid	0.3 - 770
n-Heptane	0.3 - 220
1-Heptanol	0.1 - 4.5
n-Hexane	0.6 - 1,400
1-Hexanol	0.1 - 11
Isoamyl acetate	0.1 - 32

Calibration gas	Calibration range(ppm)
Isoamyl alcohol	0.1 - 26
Isobutyl acetate	0.1 - 93
Isobutyl alcohol	0.1 - 170
Isopropyl acetate	0.5 - 330
Isopropyl ether	0.6 - 1,500
Methanol	1.1 - 3,200
Methyl acetate	1.3 - 3,800
Methyl n-butyl ketone	0.1 - 70
1-Methylcyclohexanol	0.1 - 9.6
3-Methylcyclohexanone	0.1 - 14
Methylene chloride	2.9 - 3,700
Methyl ethyl ketone	0.4 - 1,000
Methyl isobutyl ketone	0.2 - 113
n-Octane	0.1 - 110
n-Pentane	4.2 - 3,500
1-Pentanol	0.1 - 34
1-Propanol	0.1 - 330
2-Propanol	0.2 - 720

Calibration gas	Calibration range(ppm)
Propionic acid	0.1 - 56
Propyl acetate	0.2 - 190
Propyl bromide (1-Bromopropane)	0.7 - 1,600
Styrene	0.1 - 37
1,1,2,2-Tetrachloroethane	0.1 - 50
Tetrachloroethylene	0.1 - 97
Tetrahydrofuran	1.7 - 1,100
Toluene	0.1 - 290
1,1,1-Trichloroethane	0.5 - 1,200
1,1,2-Trichloroethane	0.1 - 230
Trichloroethylene	0.5 - 410
Triethylamine	0.2 - 570
m-Xylene	0.1 - 77
o-Xylene	0.1 - 67
p-Xylene	0.1 - 79

- The Dr values in the table are our measured or estimated values. For higher accuracy, we recommend actual measurement under actual conditions of use.

■ Diffusion Tube D-50/D-50-4 Data Table (Typical Example)

Liquid sample	Model	Temperature	Diffusion rate (μg/min)	Flow rate (mL/min) ※1
Toluene	D-50	50°C	1750	300
		50°C	3500	600
		35°C	1420	300
	D-50-4	50°C	3100	300
		50°C	5160	600
		35°C	1530	300

- *The diffusion rate (Dr) is based on our measured values. We recommend determining it by measurement under the actual conditions of use.
- *When using the D-50 or D-50-4, the high diffusion rate (Dr) may shorten the duration of stable gas generation.
- *Note 1: Changing the dilution gas flow rate will change the diffusion rate (Dr).