Introduction of
"Calorific Value + Specific Gravity + Wobbe Index" measuring instrument

Model: OHC-800

www.rikenkeiki.co.jp

<Contents>

1. What OHC-800 can do

Application = LNG satellite base, Gas turbine, Gas engines,
Bio-gas, Iron steel gas …etc



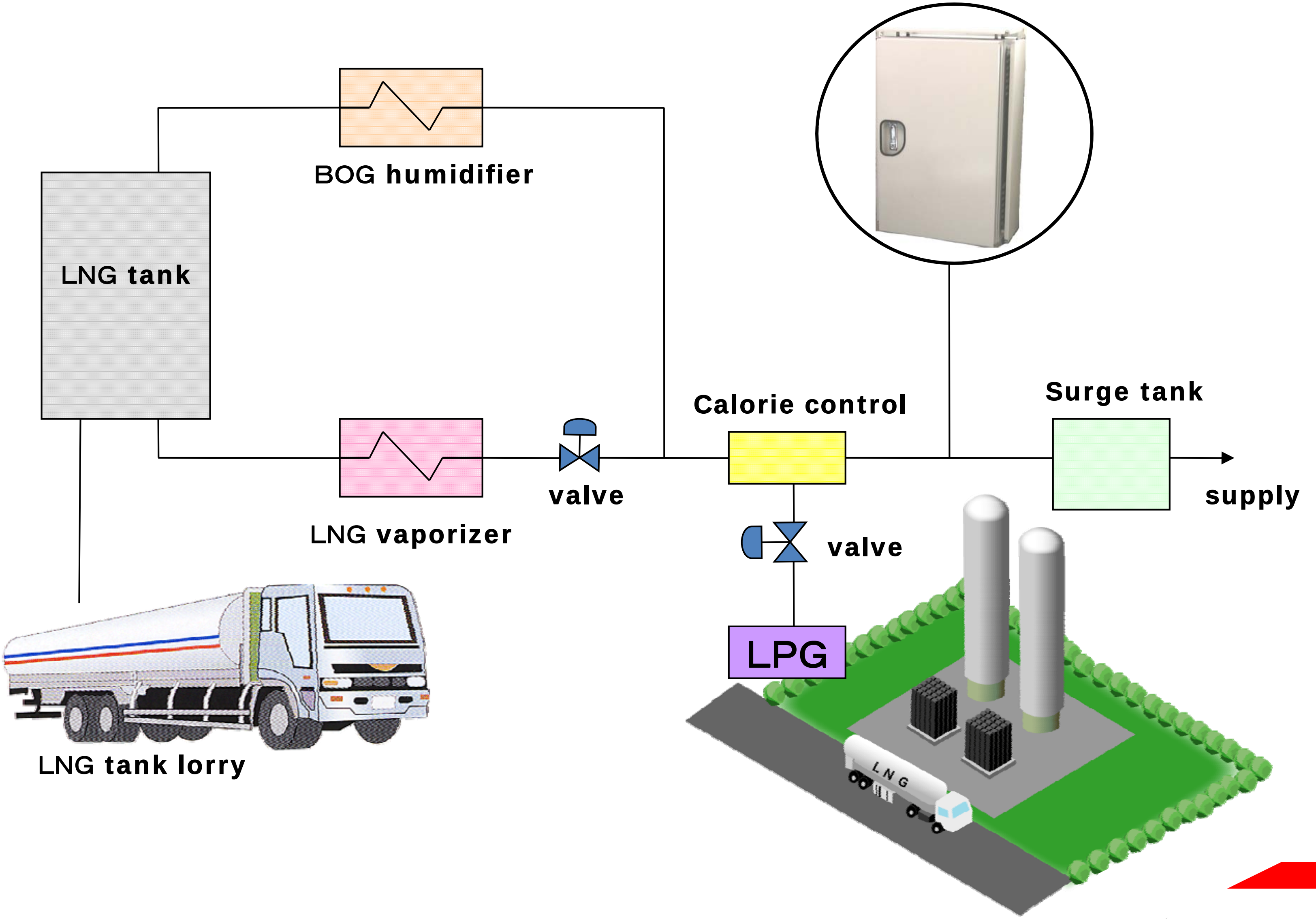

OHC-800 has various versions for various application.

One of the versions is for measuring Natural Gas (CH4 base Mix gas with interference gas concentration less than 70vol%).

Measured parameters:

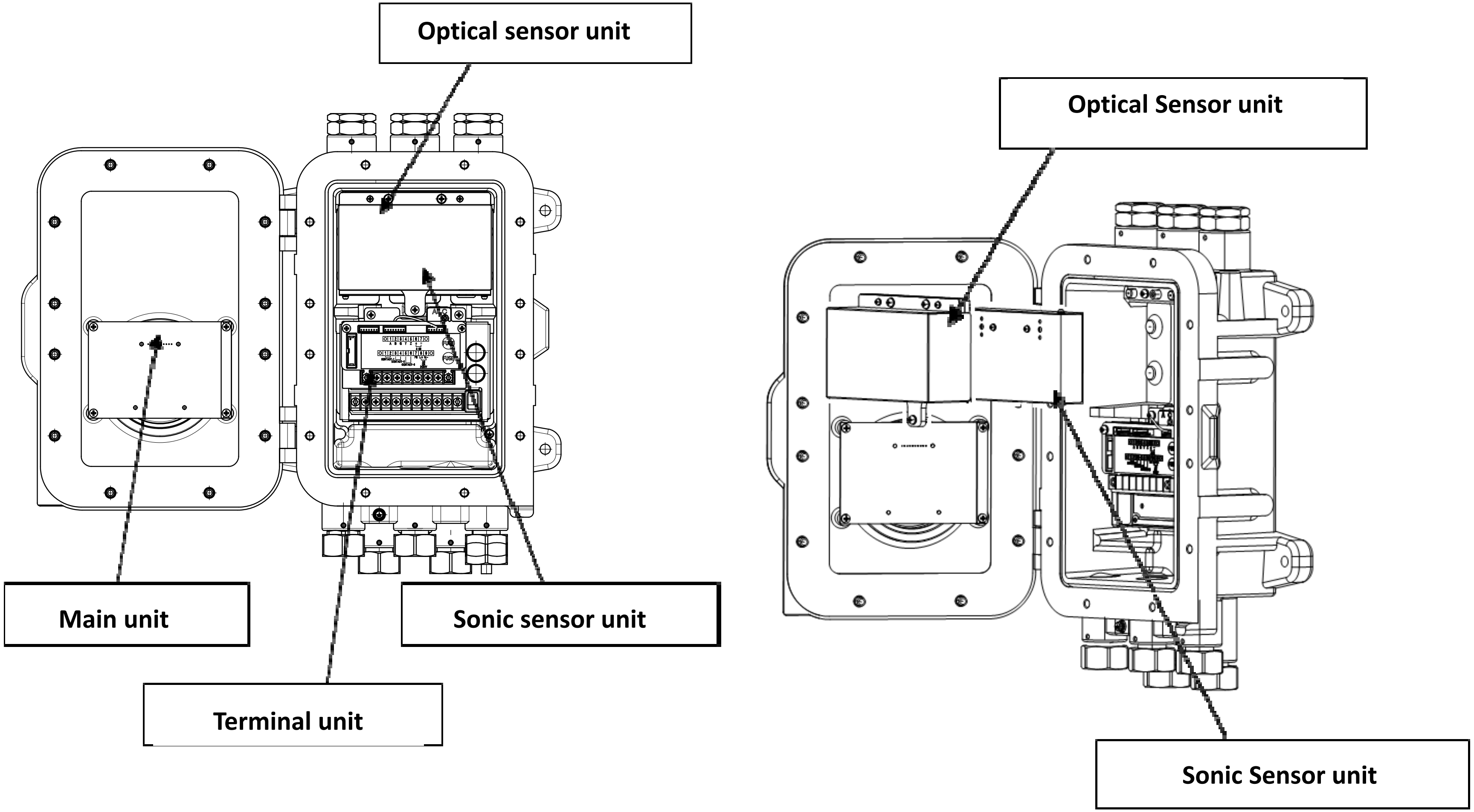
Calorific value + Specific Gravity + Wobbe Index”

Example of Natural gas measuring : LNG satellite base (NG + LPG)



2. OHC-800 introduction

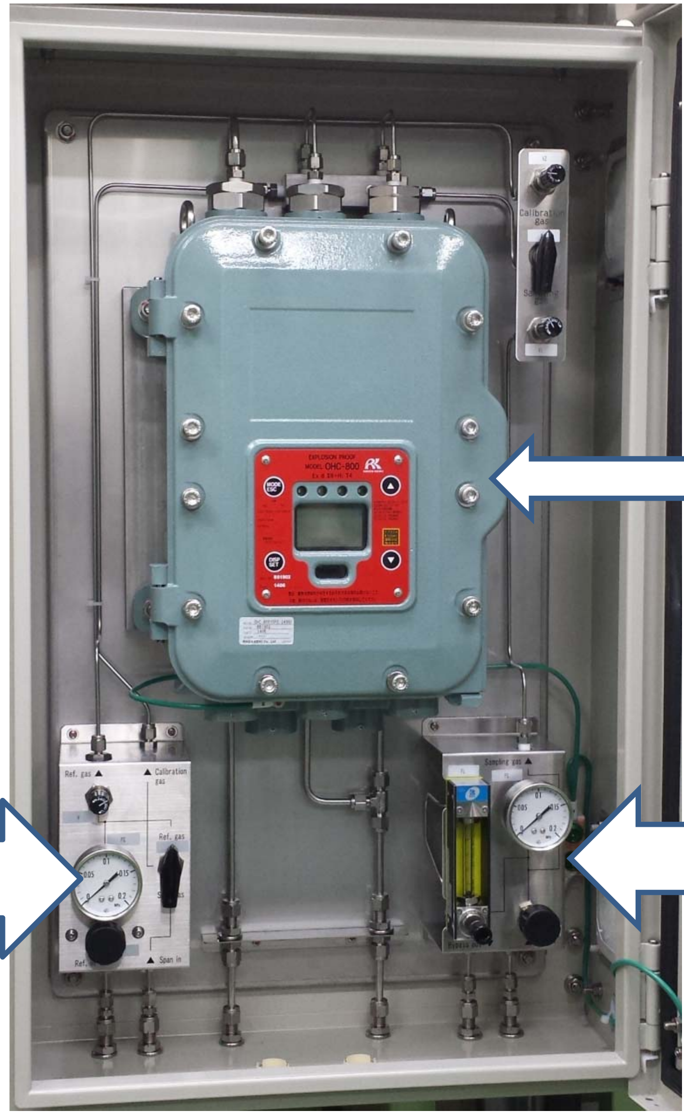
2-1. Structure -1



OHC-800 is composed of a mold body + 4 units.
(Easy to be replaced!!)

2-1. Structure -2 (OHC-800 + Sampling device)

<Inside>



Measuring unit
OHC-800

Pressure reduction unit for
Reference gas-in
(Instrument Air or N2)
0.02 to 0.9MPa, 15mL/min

Pressure reduction &
by-pass unit for
sampling gas
0.02 to 0.9MPa,
300mL/min

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2-2. Measuring principle -1 (*Opt-sonic calculation)

* **“Opt-Sonic”** is coined word by RIKEN KEIKI

Inside OHC-800, there are 2 sensors, A)”Optical sensor”(refractive index) and B) “Sonic sensor” (sound speed)

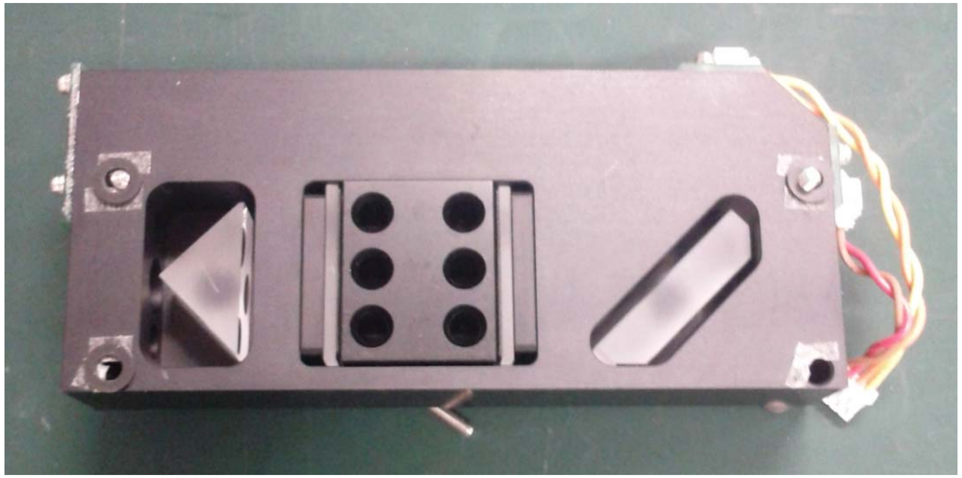
A)Optical sensor
Measuring refractive index in fuel gas

B)Sonic sensor
Measuring sonic speed in fuel gas

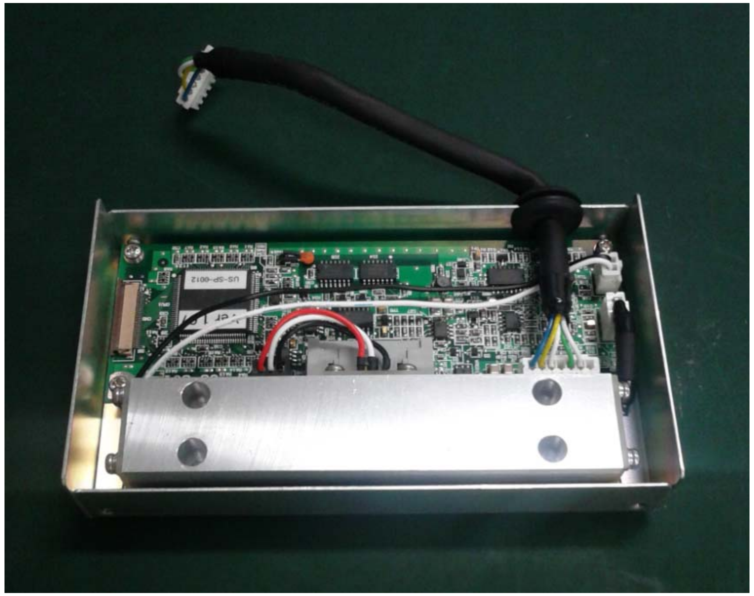
Opt-sonic calculation
PATENT No.5184983
PCT Inter national Application WO2012066828 A1

Opt-Sonic calculation enables OHC-800 to measure “Calorific value” + “Density” + “W.I.” in Natural Gas
(It is no problem even if there are some gases other than CH4 (ex. CO2, N2, O2 etc.) included in Natural Gas.)

◆ Sensor image



← Optical sensor



Sonic sensor →

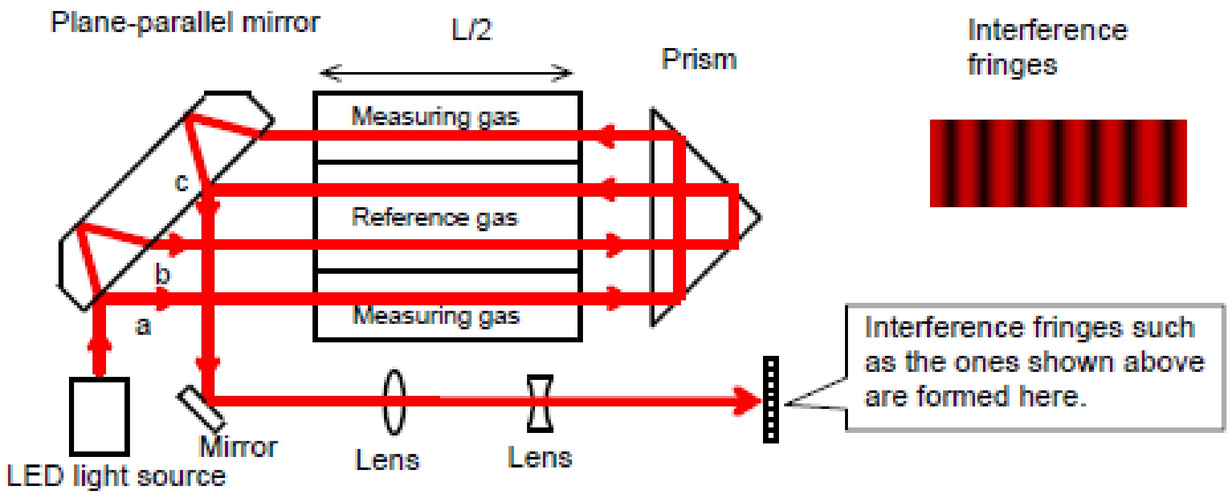
2-2 Measuring principle -2 Optical sensor (Refractive index)

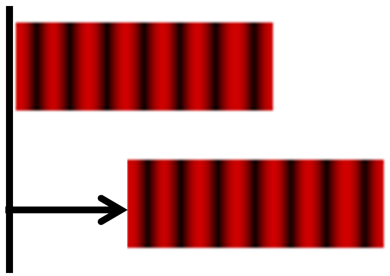
A schematic diagram of the interferometer used in the optical sensor is shown bottom of this page. This interferometer forms "interference fringes" that moves in proportion to the "differences of refractive index" between the measuring gas and reference gas.
The movement distance of interference fringes Δθ can be expressed as the following formula:

$$\Delta\theta = \frac{2\pi L(n_{GAS} - n_{REF})}{\lambda}$$

L: Chamber length
n_{GAS}: Refractive index of measuring gas
n_{REF}: Refractive index of reference gas
λ: Light source wavelength

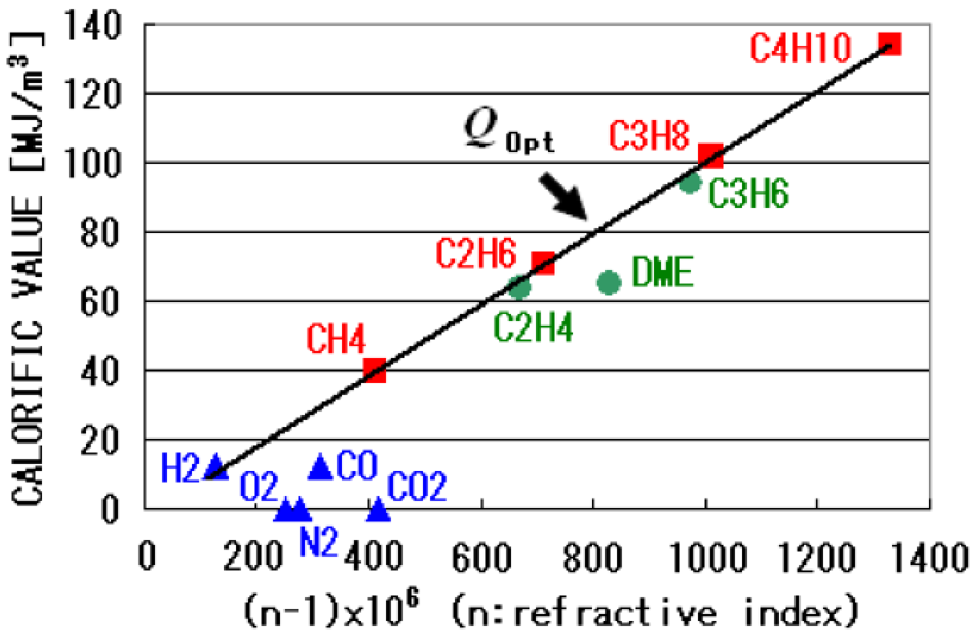
The light source wavelength and chamber length are physically quite stable. Therefore, the refractive index of measuring gas nGAS can be accurately obtained by measuring the movement distance of interference fringes.





Movement distance = Refractive index (measured by CCD camera)

Relationship between Refractive index and Calorific value



Relationship between calorific value and refractive index

Note:
Gas concentration of each gas on the figure is 100vol% (pure gas)

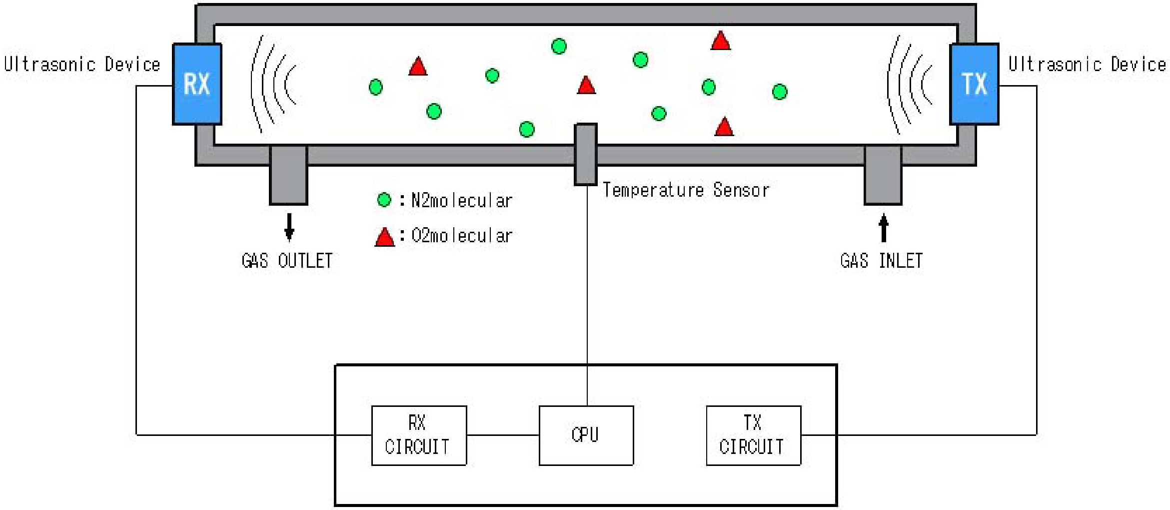
2-2 Measuring principle -3 Sonic sensor (Sound speed)

A schematic diagram of the sonic sensor is shown the bottom of this page. This sensor emits a sound from the sound source into a chamber (where a measuring gas flows), and measures the time τ in which the sound travels through the measuring gas (from the sound source to the sound receiver). The sound speed that travels through the measuring gas vGAS is expressed as below.

$$v_{GAS} = \frac{L}{\tau}$$

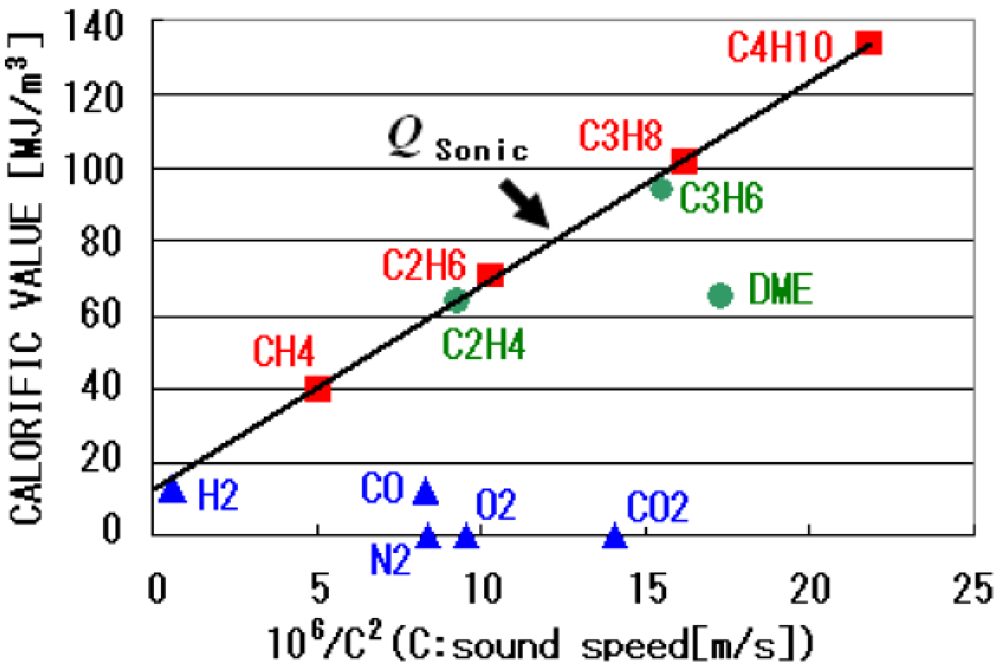
L: Distance from the sound wave source to the sound receiver
τ: Time in which a sound from the sound source arrives at the sound receiver

The distance from the sound source to the sound receiver L is physically quite stable. Therefore, the speed at which a sound travels through the measuring gas vGAS can be accurately obtained by measuring the sound travel time τ.



When natural gas is supplied into the chamber, the sound speed becomes faster.

Relationship between Sound speed and Calorific value



Relationship between calorific value and sound speed

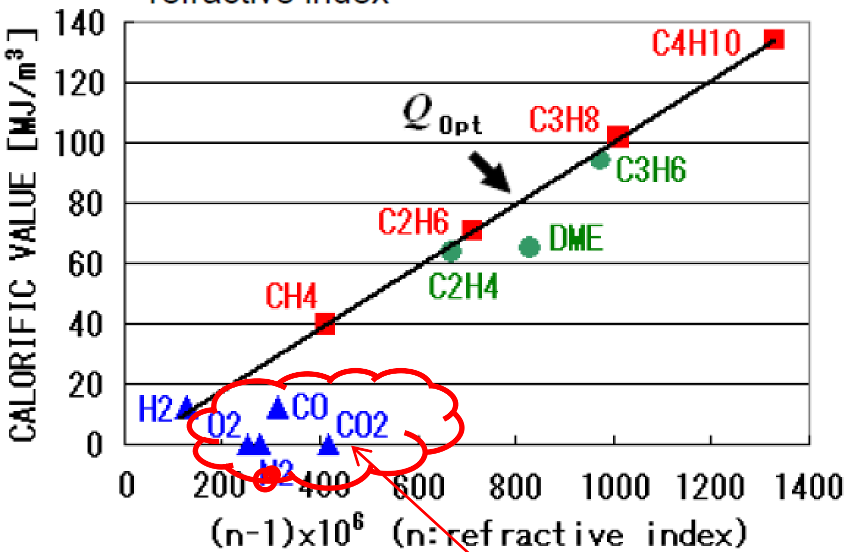
Note:
Gas concentration of each gas on the figure is 100vol% (pure gas)

2-2 Measuring principle -4　Opt-sonic measurement

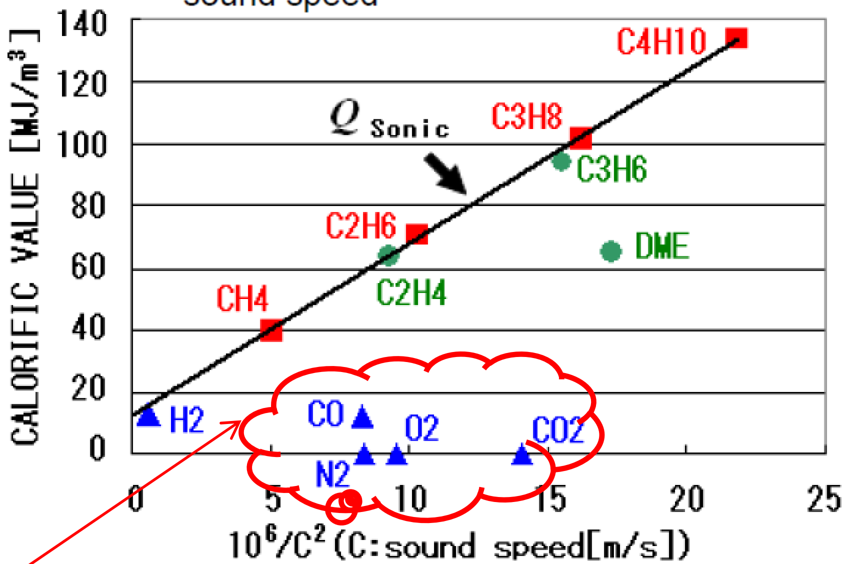
If the gas to be measured consists only of paraffinic hydrocarbon gases (C1,C2,C3…), an accurate calorific value can be obtained by measuring sound speed or refractive index.

However, it is true that Calorimeter based on individual Optical sensor or Sonic sensor has interference effects on the its measuring result if N2, O2, CO2,CO etc. are contained in the measuring gas. Because of this interference effects, the measured calorific value (by individual optical sensor, or sonic sensor) is not accurate enough to be used as a Calorimeter or Methane Number monitor.

Relationship between calorific value and refractive index



Relationship between calorific value and sound speed



Regarded as interference gases, affecting on the measuring results!!

Introducing Opt-Sonic calculation

The relationship between the true calorific value of the measuring gas Q and the functions QSonic and QOpt can be expressed by the following formulas (1) and (2).

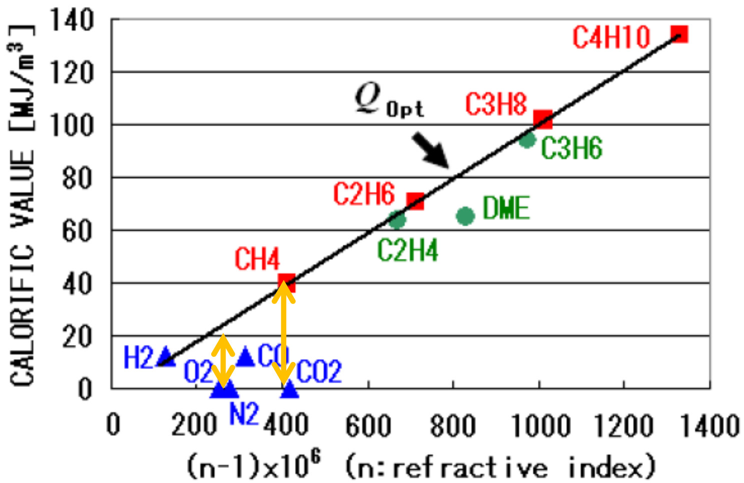
$$Q = Q_{\mathrm{Opt}} - \sum k_{\mathrm{i}} \cdot x_{\mathrm{i}} \quad (1)$$

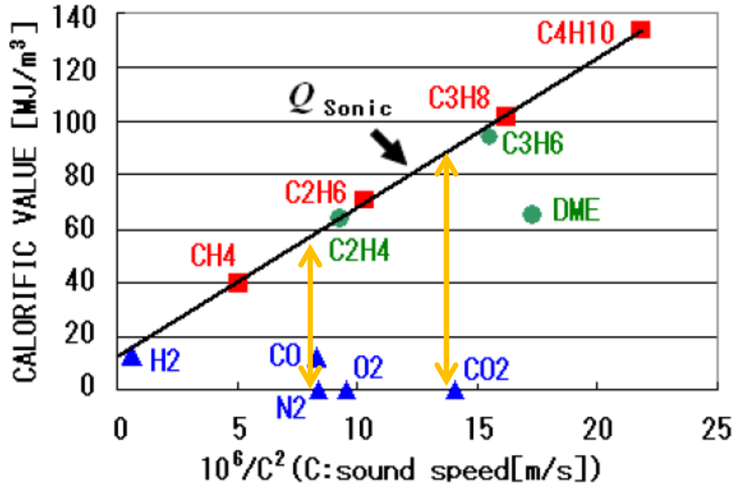
$$Q = Q_{\mathrm{Sonic}} - \sum k'_{\mathrm{i}} \cdot x_{\mathrm{i}} \quad (2)$$

xi = volume fraction of interference gas component i,
ki and k'i = error coefficients caused by interference gas component i.

The error coefficients ki and k'i represent the "distances" in a vertical axis direction from the component i to the straight lines drawn by the functions QSonic and QOpt in the graphs shown in Figures 1 and 2. RIKEN KEIKI has discovered a relationship in which the ratio of ki to k'i is approximately constant, regardless of the types of interference gases.

$$k'_{\mathrm{i}} \approx \alpha \cdot k_{\mathrm{i}} \quad (3)$$





Introducing Opt-Sonic calculation

Using the relational formula (3), the formula (2) can be written as follows:

$$k'_{\mathrm{i}} \approx \alpha \cdot k_{\mathrm{i}} \qquad (3)$$

$$Q = Q_{\mathrm{Sonic}} - \sum k'_{\mathrm{i}} \cdot x_{\mathrm{i}} \qquad (2)$$

⬇

$$Q \approx Q_{\mathrm{Sonic}} - \alpha \cdot \sum k_{\mathrm{i}} \cdot x_{\mathrm{i}} \qquad (4)$$

The formulas (1) and (4) can be used to derive the relational formula of the Opt-Sonic calculation for obtaining calorific value.

$$Q = Q_{\mathrm{Opt}} - \sum k_{\mathrm{i}} \cdot x_{\mathrm{i}} \qquad (1)$$

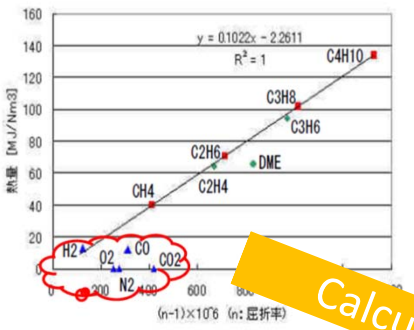
$$Q \approx Q_{\mathrm{Sonic}} - \alpha \cdot \sum k_{\mathrm{i}} \cdot x_{\mathrm{i}} \qquad (4)$$

⬇

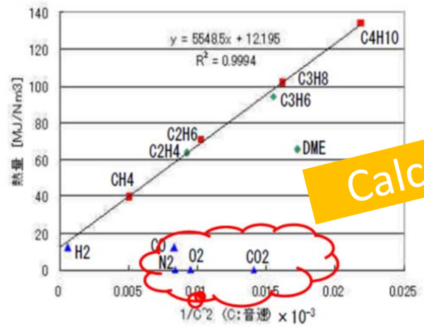
$$Q \approx Q_{\mathrm{Opt}} - \frac{Q_{\mathrm{Opt}} - Q_{\mathrm{Sonic}}}{1 - \alpha} \qquad (5)$$

By using the formula (5)…

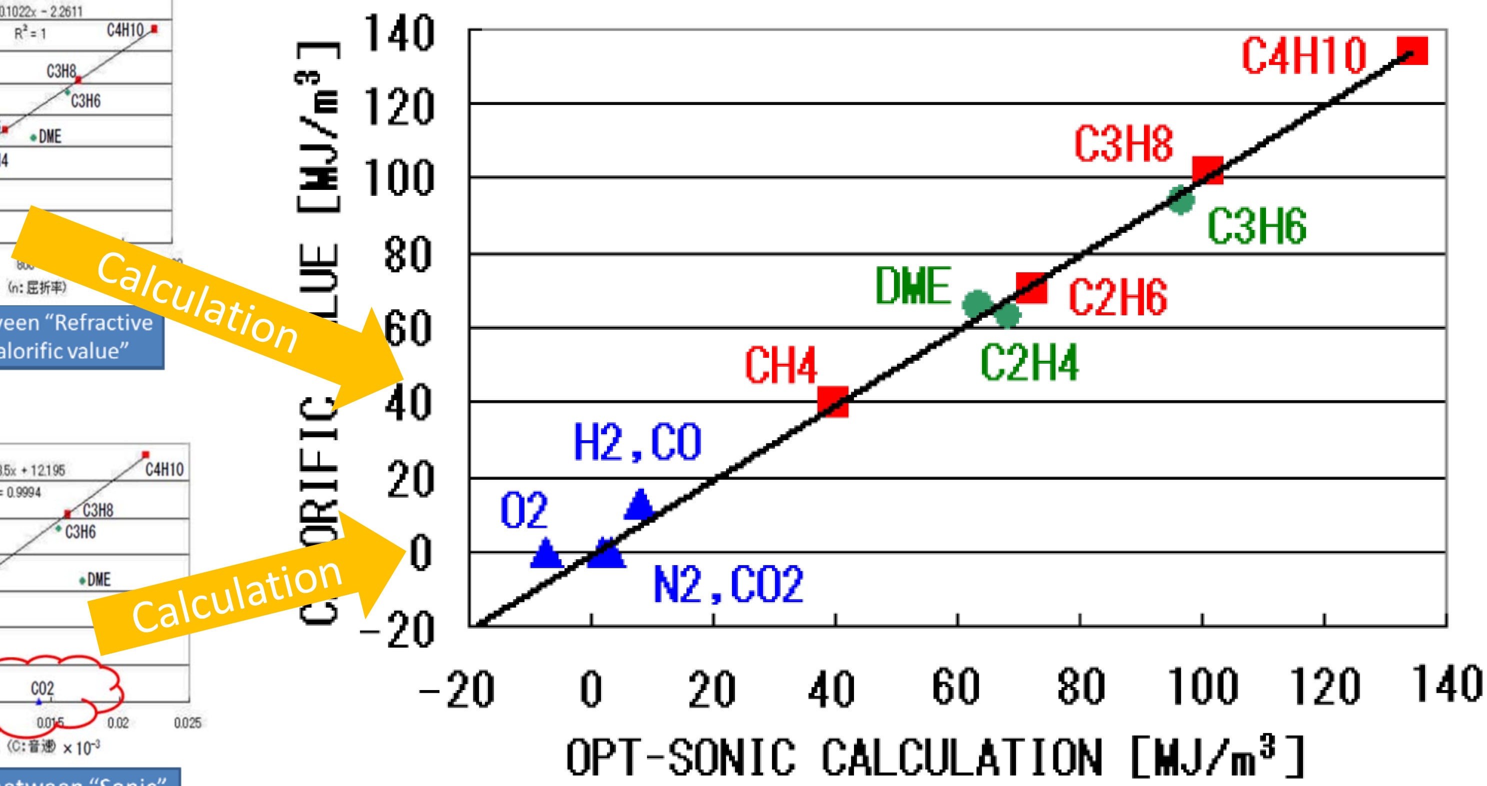
$$Q \approx Q_{\mathrm{Opt}} - \frac{Q_{\mathrm{Opt}} - Q_{\mathrm{Sonic}}}{1-\alpha} \qquad (5)$$



Correlation between "Refractive index" and "Calorific value"



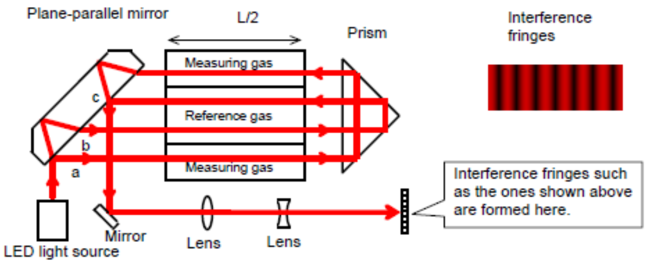
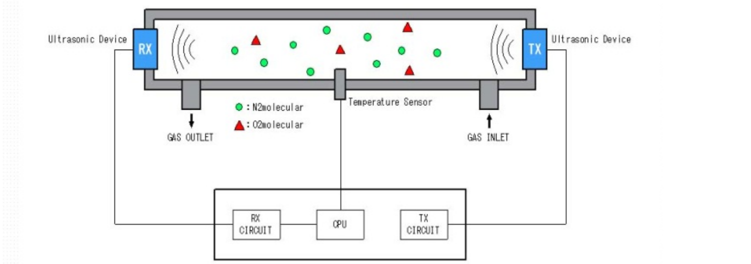
Correlation between "Sonic" and "Calorific value"



Relationship between Opt-Sonic calculation and calorific value

Minimum interference effects on a measuring result even if N2, O2, CO2,CO etc. are contained in the measuring gas!!

2-2 Measuring principle -6   Strong points of sensors

Optical sensor	**Sonic sensor**
	
< Physical sensor > Chamber length is unchanged LED light source is capable of emitting the stable wave length	< Physical sensor > Chamber length is unchanged Sound pressure is varied as time passes, but the sound pressure does not affect on the sensitivity.

Both sensor is Physical based sensor.
(No chemical reaction, No burning …etc.)

↓

- **No calibration is required (Sensitivity is stable for very long time)**
- **No consumables is required**

↓

Periodic maintenance works after installation are not required!!

3. OHC-800 Advantage

OHC-800 advantage

3-1. Accurate, quick and continuous measurement

3-2. Measurable in Hydrogen mixed gas stream

3-3. Install available to various location

3-4. Low maintenance cost

3-5. Self diagnosis and easy unit replace design

3-6. Data logger and data analysis service

3-1. Accurate, quick and continuous measurement

◆**Accurate**

⇒**Measurement accuracy : ±0.4% of reading (CV)**

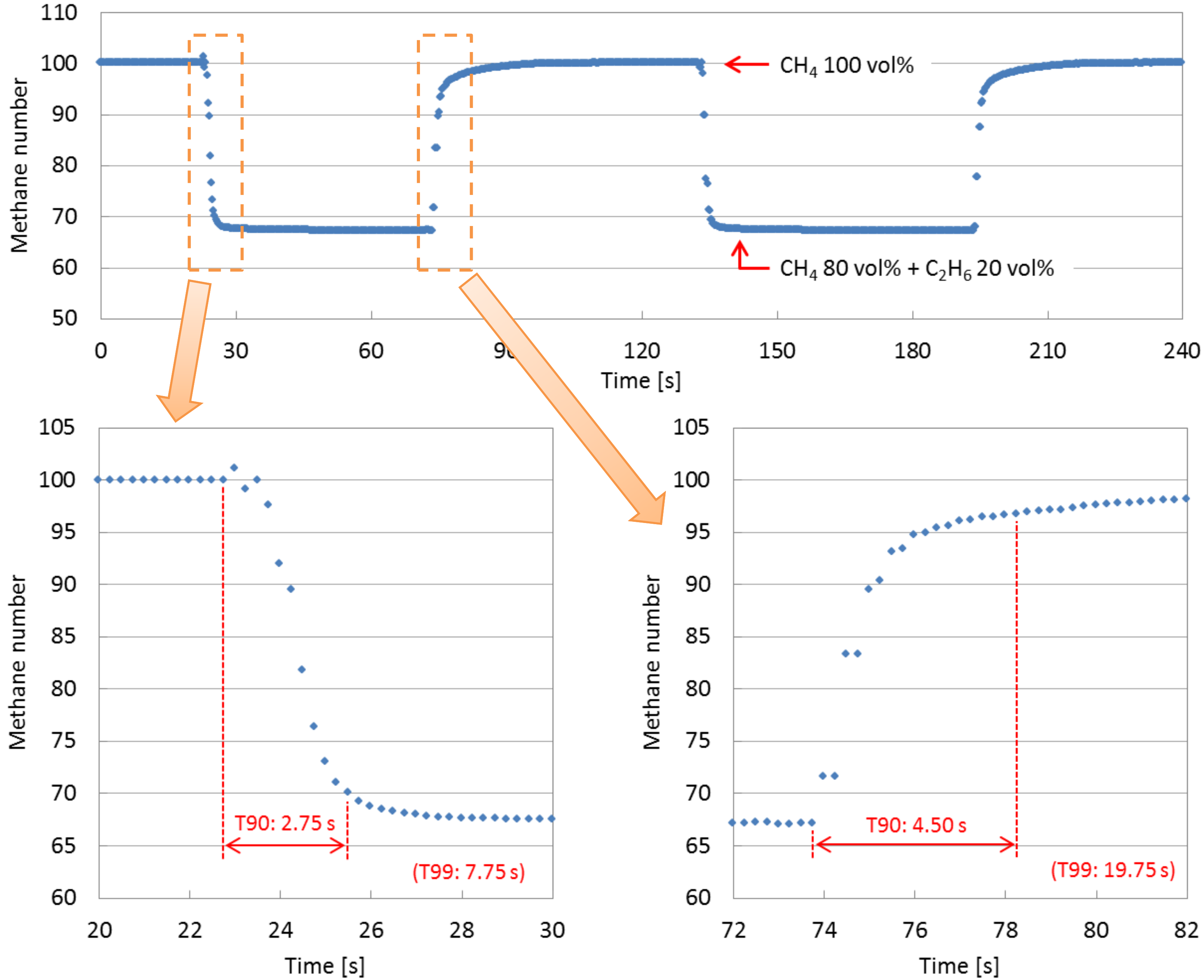
◆**Quick**

⇒**Response time : Within 5 seconds (T90 reaction)**

◆**Continuous**

⇒**Real-time measurement for continuously**

Response time and Repeatability



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3-2. Measurable in Hydrogen mixed gas stream

	Composition, vol%						ISO 6976			OHC-800			Error, %		
							calorific value		specific gravity	calorific value		specific gravity	calorific value		specific gravity
	CH_4	N_2	CO_2	O_2	H_2	C_2H_6	MJ/Nm^3, Gross	BTU/ft^3, Gross	AIR=1	MJ/Nm^3, Gross	BTU/ft^3, Gross	AIR=1	MJ/Nm^3, Gross	BTU/ft^3, Gross	AIR=1
A	30		70				11.98	304.2	1.238	11.86	301.2	1.235	0.98	0.98	0.17
B	30	10	60				11.98	304.1	1.181	12.07	306.6	1.178	-0.83	-0.83	0.29
C	30	8	60	2			11.98	304.1	1.184	11.85	300.8	1.181	1.08	1.08	0.26
D	40		60				15.97	405.5	1.140	15.95	405.1	1.137	0.11	0.11	0.22
E	40	10	50				15.97	405.5	1.084	16.12	409.3	1.081	-0.94	-0.94	0.27
F	40	8	50	2			15.97	405.5	1.086	15.88	403.2	1.084	0.57	0.57	0.21
G	50		50				19.96	506.9	1.043	20.06	509.3	1.038	-0.47	-0.46	0.41
H	50	10	40				19.96	506.8	0.986	20.16	512.0	0.983	-1.03	-1.03	0.35
I	50	8	40	2			19.96	506.8	0.989	19.92	505.9	0.986	0.20	0.20	0.27
J	80	20					31.95	811.2	0.638	32.30	820.1	0.630	-1.10	-1.10	1.31
K	80		20				31.94	811.1	0.750	32.03	813.4	0.744	-0.28	-0.28	0.82
L	80	10	10				31.94	811.1	0.694	32.20	817.7	0.686	-0.81	-0.81	1.16
M	100						39.94	1014.1	0.555	39.95	1014.4	0.551	-0.04	-0.04	0.77
N	60				40		29.05	737.8	0.361	29.07	738.1	0.365	-0.05	-0.05	-1.11
O	80				20		34.49	875.8	0.458	34.47	875.3	0.457	0.06	0.06	0.20
P	40		30		30		19.79	502.4	0.701	19.94	506.3	0.710	-0.76	-0.76	-1.27
Q	65				30	5	33.29	845.4	0.434	33.16	842.0	0.436	0.40	0.40	-0.49

OHC-800 can measure a gas stream with Hydrogen

3-3. Install available to various places

◆**Explosion proof : IECEx / ATEX Ex d IIB + H2 T4 Gb**
⇒**Installable to hazardous area**

◆**Operating temperature : -20 to +60 degree C**
⇒**Installable to the variety of temperature condition**

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3-4. Low maintenance cost

◆No calibration is required (Sensitivity is stable for very long time)
⇒Periodic maintenance works after installation are not required
No calibration gas is required

◆No consumables is required
⇒Periodic maintenance works after installation are not required

◆Instrument Air can be used as Reference gas
⇒No reference gas is required
(Nitrogen can be used as reference gas, if required)

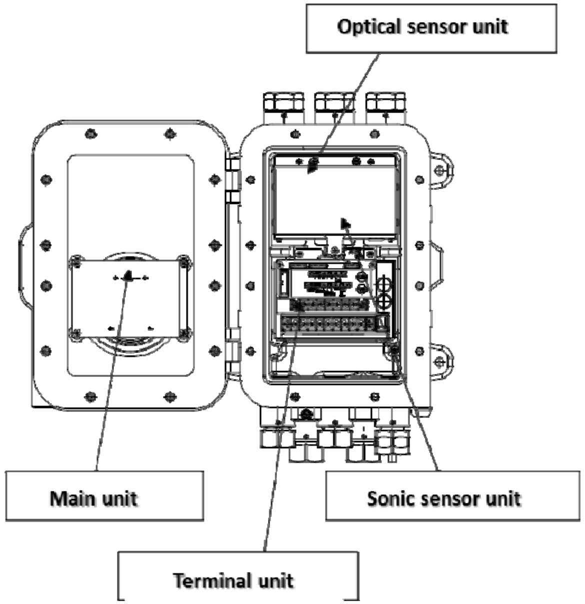
3-5. Self diagnosis and easy unit replace design

◆Self diagnosis function

⇒ 4 condition "FAILURE", "FUNCTION CHECK", "OUT OF SPECIFICATION", "MAINTENANCE REQUIRED" are self-monitored, and activate alarm immediately when some abnormal condition is monitored.

◆ Easy unit replaceable design

⇒ OHC-800 is composed of 4 parts.
If some abnormal condition is monitored by the self-diagnosis function, and some part replacement is needed, it is only required to replace the deteriorated unit to the new unit. No further adjustment required after the unit replacement.



3-6. Data logger and data analysis service

◆Data logger

< DAILY LOG >

Collect data every 3 hours. Max. 3519 data can be stored (for 439 days)

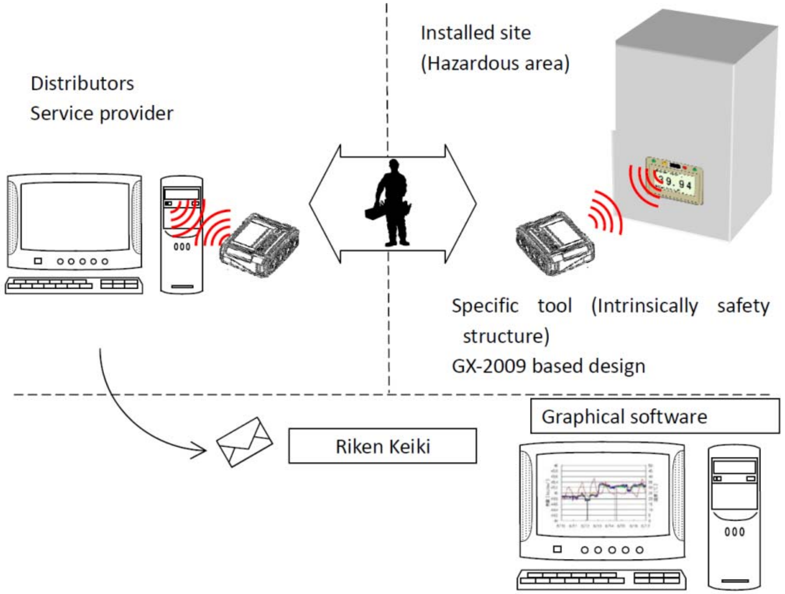
- ・Recorded Date & Time
- ・Measured value, Temp./Pressure…etc
- ・Data of sonic sensor unit for 20 minutes before data collection (1 minute interval × 20 times)
- ・Data of optical sensor unit for 20 minutes before data collection (1 minute interval × 20 times)
- ・Trouble flag/Self-diagnosis flag…etc.

< EVENT LOG >

Data for 1 minute just after particular kind of event is caused (6 seconds interval × 10times)
Max.64 data can be stored.

◆ Data analysis service

Logged data can be downloaded by using a specific tool (GX-2009DL).
If some abnormal operation is found on the OHC-800, send the data to RIKEN KEIKI, so that RIKEN KEIKI will do data analysis and provide some feedback to customers.



Specifications

Measuring unit OHC-800 (SPE-2725)	
Measuring range for Calorific value	10.00 to 50.00 MJ/m^3 (Gross, 0 ℃, 101.325 kPa)
Measuring range for density	0.500 to 1.500 (Specific gravity conversion Air=1)
Combustion index	Wobbe Index
Output signal	4 to 20 mA DC (Select one from MN, Calorific value, Specific gravity) RS-485 Modbus
Repeatability	±0.02 MJ/m3 (CV) / ±0.002 (SG)
Measurement Accuracy	±0.4% of reading (CV) (SG)
Drift by temperature	0.20 MJ/m3 (CV) (Fluctuating range 20 ℃)
Response time (T90)	Within 5 sec (Flow rate 300mL/min)
Measuring gas	Natural Gas (CH4 base Mix gas with interference gas concentration less than 70vol%)
Sampling device	
Pressure for Gas-in	0.05 to 0.9 MPa
Pressure for Reference-in	0.05 to 0.9 MPa
Gas-out	Release to atmosphere or exhaust duct with Atmospheric pressure ±3 kPa
Reference-out	Release to atmosphere or exhaust duct with Atmospheric pressure ±3 kPa