CWD

Calorimetry Measuring Devices

- Measurement of Wobbe index and specific gravity
- Direct determination of the heat of reaction
- Calculation of net and gross calorific value/heating value
- Use in potentially explosive atmospheres
- Approval for calibration measurements
- Integrated computer for control and evaluation




Gas composition and CWD product series

Gas composition, Wobbe index

Natural gas and other combustible gases have gained high importance as fuels for industrial processes. Depending on their origin, they differ significantly in their chemical composition and combustion behaviour. The technical terms are "gas composition" or "gas properties" which desrcibe characteristics such as heating value, calorific value and Wobbe index (see textbox below).

In view of the increasing diversification of natural gas sources, consumers are increasingly supplied with natural gas with varying gas composition and thus different combustion behaviour. If the gas consumer is a thermally sensitive process or burner, the composition of the gas supplied must be monitored and, if necessary, adjusted to the required value by conditioning. Otherwise the function of a burner and of the downstream process and hence also the product quality are jeopardised. Typical examples are processes in the glass industry and in metallurgy. A similar effect is created by the increasing use of biogas and bio-methane or process gases (blast furnace gases) as combustion gases.

CWD calorimeter series

A suitable gas measurement technology is required to master the variations in the gas composition while supplying heat to processes - UNION Instruments has been offering this technology with its extensive CWD device series for many decades.

CWD is a mnemonic of the terms **C**alorimetry, **W**obbe index and specific **D**ensity and designates a modular product series for determining calorimetric values in gases according to the DVGW codes of practice G260 and G262 (see page 7),

Figure 1 gives an overview of the different CWD variants with their manifold ranges of application, including custody transfer measurements (CT) and the determined parameters. Parameters measured are the Wobbe index and specific gas density, from which the heating value and calorific value are calculated.

For details on the device design refer to page 4, for technical data to page 6.

CWD Device series	Application segment			Special feature		Measured values	
	Natural gas Biomethane Liquid gas	Low gas Furnace gas Coke gas Mixed gases	High gas Refineries Mixed gases	Hazardous areas Class I Div. II	Custody transfer measur.	Measured values	Calculated values
CWD 2005	X	X	X			Wobbe Index Specific density	Heating value Calorific value
CWD 2005-CT	X				X		
CWD 2005-DP	X		X	X			
CWD 2005-PLUS	X		X				
W 2005	X	X	X			Wobbe Index	Heating value Calorific value (at constant density)

CT: Custody Transfer DP: Direct Purge

Figure 1

Net calorific value

Maximum usable heat upon combustion of a gas without condensation of the water vapour in the exhaust gas.

Gross calorific value

Maximum usable heat upon combustion of a gas with condensation of the water vapour in the exhaust gas.

Wobbe Index (Wobbe number, kWh/m³)

Indicator of the interchangeability of combustion gases with respect to the thermal load on the burners. Important when using combustion gases of changing composition in one burner. If combustion gases of different composition have the same Wobbe index and the same flow pressure at the burner, they have approximately the same heat capacity.

Wobbe index - Direct or indirect determination

Wobbe index

The Wobbe index of a gas is a corrected heating value (see equation 1) and serves as an index for the interchangeability of combustion gases at burners. Gases of different chemical composition but with the same Wobbe index are equivalent in terms of burner load and can be interchanged without jeopardising the burners. For safe and efficient operation of a combustion system, the Wobbe index must therefore be continuously determined before the combustion gas enters the burner. For this purpose, direct and indirect determination methods are in use.

Direct determination (principle of the CWD)

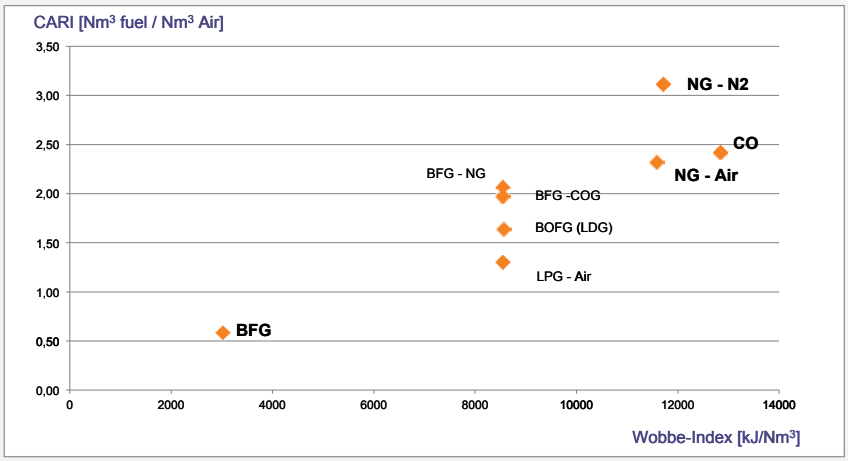
All devices of the CWD series use the direct measurement method to determine the Wobbe index: Continuous measurement of the energy generated by the combustion of a defined gas flow determines the Wobbe index directly. In addition, the specific gravity is measured which can serve to calculate the heating value. A correlation function is not required at any point.

Even unknown and unexpected components in the gas are determined during combustion and taken into consideration in the measurement. That is of great importance with rapidly changing gas compositions of e.g. residual gases from chemical processes or substitute gases in the steel industry.

Indirect determination

Many Wobbe devices do not determine the Wobbe index directly; they determine the residual oxygen remaining in the gas after a leaner-than-stoichometric, catalytic combustion of the gas. Once this indirect value is determined by means of gas analysis, the air requirement is calculated and then, after its correction, the characteristic CARI (**C**ombustion **A**ir **R**equirement **I**ndex) for combustion. Finally, the Wobbe index is determined from CARI (see equation 2) via a correlation function.

The precision that can be achieved with this method depends on how the catalyst influences the completeness of the combustion and on the precision with which the used correlation function represents the respective application (i.e. the current gas mix). Studies in the steel industry have shown that when using "substitute gases", faults cannot be ruled out as frequently used gas mixtures are positioned outside the typical correlation curves. Figure 2 shows this situation: There is a by no means clear correlation between the Wobbe index and CARI for gases typically used in the steel industry. The following gases (and their mixtures) are plotted:



NG	Natural Gas
BFG	Blast Furnace Gas
BOFG	Basic Oxygen Furnace Gas
LPG	Liquified Petroleum Gas
LDG	Linz Donawitz Gas
COG	Coke Oven Gas

Figure 2: Non-linear correlation between CARI and Wobbe index (steel industry)

Wobbe index

$$\frac{\text{Heating value}}{\sqrt{\text{Specific gravity}}} \quad (1)$$

CARI

$$\frac{\text{Air demand}}{\sqrt{\text{Specific gravity}}} \quad (2)$$

Specific gravity

$$\frac{\text{Density fuel gas*}}{\sqrt{\text{Density air*}}} \quad (3)$$

**At the same conditions*

Device structure and device function

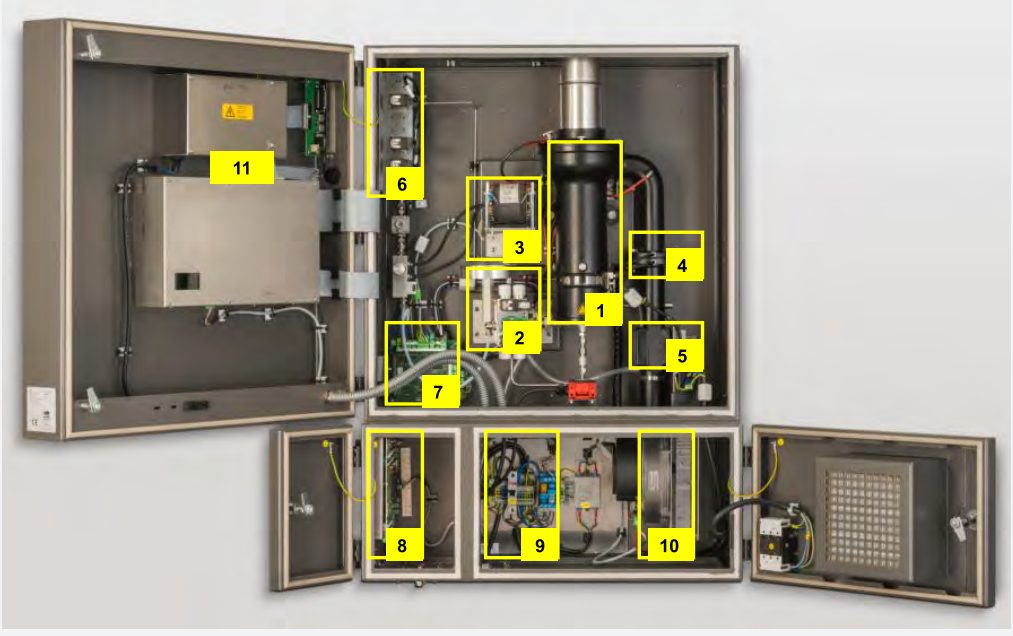


Figure 3: Device layout CWD

The sample gas is combusted in the measuring cell with burner (1). The flame is detected via the energy release on successful ignition. To determine the energy quantity, the temperature increase is determined directly in the exhaust gas flow using very rugged thermocouples. This allows for particularly fast measurement of heating value variations of the sample gas.

The low-pressure gas supply (2) offers the user a number of advantages:

- The inlet pressure of only 25 - 35 mbar allows the use of a pressure booster pump to be eliminated in many cases. This also eliminates a possible source of errors because the compression of vapour-saturated gases (e.g. boiler gases) generates condensation which impairs the subsequent measurement. This influence is deliberately minimised in the CWD by the low inlet pressure.
- The metering technology of the CWD enables measurements with small gas flows from 10 l/h. This allows the entire sample gas to be combusted. This eliminates the problems otherwise encountered by the user of the gas disposal.
- For precise measurement of the Wobbe index, the gas must be metered with high precision. In the CWD, this is ensured by a system of pressure controller and nozzle: The precision pressure reducer from UNION Instruments is temperature independent and can control pressure differentials of 4 mbar in constant operation. The measuring range is determined by a gas nozzle with a diameter of 0.4-1.5 mm.

The acoustic density measurement (3) is performed in the bypass to the main sample gas flow. If offers a wide measuring range from 0.2 to 2.2 relative density.

The air measurement (4) is performed via a measuring orifice and a precision differential pressure sensor.

The gas is supplied (6) via a valve block which controls the supply of sample gas and calibration gas to the analyser. In device variants approved for custody transfer, a "block and bleed" circuit with increased security is used.

The **other modules** in Figure 3 are

(5) Automatic ignition device
(7) Data logger
(8) I/O section
(9) Power supply
(10) Fan
(11) Electronics/power supply unit

Acoustic density measurement of gases

The piezoelectric effect converts mechanical deformations into electric signals and vice versa.
One of the many applications is the acoustic density measurement of gases with particularly high linear measuring range (0.0 - 2.0 relative density). **The piezoceramics used for this in the CWD** are gold-plated and therefore extremely corrosion-resistant. The measurement is performed in the bypass with a very small gas throughput (1-4 l/h) and hence very low risk of soiling. The high measurement precision allows the Wobbe index to be converted into calorific value even for custody transfer measurements for natural gas.

Control system (hardware and software)

Control and operation
The operating unit HMI (Human Machine Interface) comprises the components central control unit, display and keyboard and is linked to two modules via the device bus (Figure 4): The measurement technology module collects the measurement data, the I/O module controls the external communication. The details of the user interface are shown in Figure 5.

The software
is based on a real-time operating system. It is structured in various menu levels which are reached via softkeys.

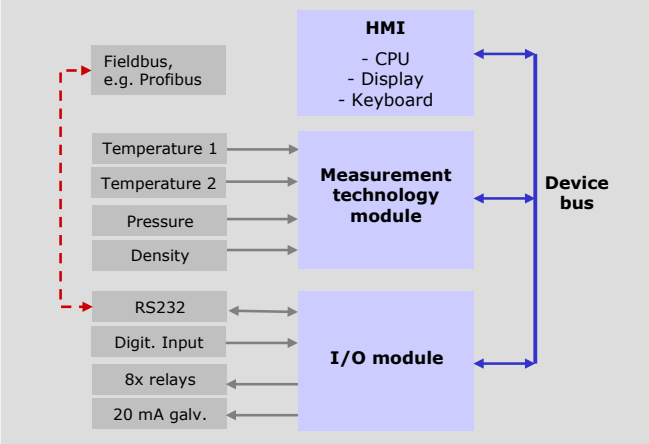


Figure 4: CWD function flowchart

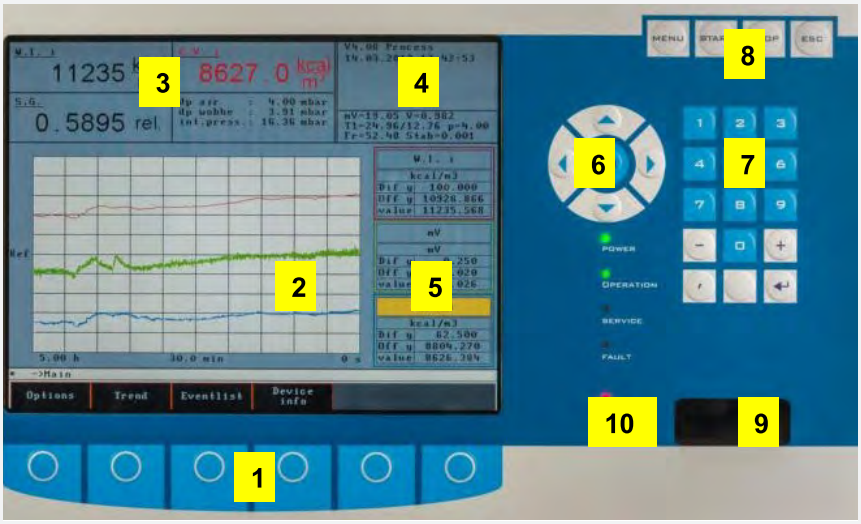


Figure 5: Operation and display panel CWD (Human Machine Interface)

1: Menu keys (softkeys)
2: Current measurement data (graphic display)
3: Current measurement data (numerical, with dimension)
4: Info field (date, time, internal operating data, ..)
5: Trend displays
6: Position keys
7: Input keys
8: Start/Stop
9: Burner window (for observing the flame)
10: LED status displays

Fieldbus
Term for serial communication bus systems in production and process automation in which field devices such as sensors, measurement devices and actuators (slaves) are connected to control systems (masters). The bus enables bidirectional communication among the bus participants for digital data exchange. The most successful field bus worldwide is Profibus. Fieldbuses are increasingly replacing the conventional 4-20 mA technology.

CWD - Technical data

	CWD2005	CWD2005-CT	CWD2005-DP	CWD2005-PLUS	W2005
Weight [kg]	54	54	54	54	54
Dimensions (WxHxD) [cm]	72 x 102 x 33.7				
IP degree of protection	IP 50				
Ex-proof classification	none	none	Class I, Div, 2	none	none
Setup site	safe zone	safe zone	Zone 2	safe zone	safe zone
Operating temperature	5° - 40° C				
Inputs of process gas	max. 2	1	1	max. 2	max. 2
Inputs of calibration gas	max. 2	1	1	max. 2	max. 2
Tests (optional)	SGS (NRTL-accredited)				
Mains supply	240 VAC 50 Hz / 240 VAC 60 Hz / 110 VAC 60 Hz				
Max. power consumption	200 VA				
Storage temperature	0° - 60° C				
CSA approval (optional)	√	(√)	√	√	√
Interfaces	4-20mA, RS232, relay contacts, Ethernet (TCP/IP), Profibus-DP, Modbus-TCP, Modbus-RTU, Profinet IO				

Measuring ranges / precision / gas quantity						
Range MJ / m³	**Gas type**	**Precision Wobbe index [±% MBE] / gas quantity [l/h]**				
0 - 15	Flare gas	3.0 / 40	–	3.0 / 40	–	3.0 / 40
3.5 - 6	Blast furnace gas	3.0 / 170	–	–	–	3.0 / 170
4.5 - 9	Converter gas	1.5 / 140	–	–	–	1.5 / 140
5 - 10	Mixed gas	2.0 / 140	–	–	–	2.0 / 140
15 - 30	Coke-oven gas	1.5 / 60	–	1.5 / 60	1.5 / 60	1.5 / 60
25 - 35	Biogas	1.5 / 70	–	1.5 / 70	1.5 / 70	1.5 / 70
25 - 50	Refinery gas	1.5 / 25	–	1.5 / 25	1.5 / 25	1.5 / 25
30 - 48	Natural gas	1.5 / 25	1.0 / 25	1.0 / 25	1.0 / 25	1.5 / 25
40 - 90	LPG	1.5 / 15	–	1.5 / 15	1.5 / 15	1.5 / 15

Figure 6: Technical data of the CWD devices

Ethernet
Term for a communication technology for data exchange among devices in a network with especially high transfer rates. In its variant "Industrial Ethernet", Ethernet is the accepted industry standard on the level of interlacing control systems and implementing control technology to higher levels. Particularly in combination with other protocols, Ethernet is widely used in the form of Ethernet-based solutions such as PROFINET or Modbus TCP. PROFINET in particular is both Industrial Ethernet and 100% Ethernet and is therefore suitable for all industrial applications and also for the use of all web-based services and tools.

CWD – Applications

There are many applications for CWD devices, both with regard to the gases to be measured and to the process-engineering aspects (industries) and applications in the production lines. Figure 7 provides an overview. Special CWD device variants allow use in custody transfer traffic and operation in potentially explosive areas.

Use in custody transfer

Calibration laws require that measuring devices used in commercial business (purchase and sale of measurable goods) must be calibrated. This is referred to as custody transfer.

This is of special importance in the oil and gas industry because of the immense volume and energy flow moved in that field and deliverd between different supplieres or to consumers.This obligatory calibration also applies to calorimeters for the calorific value of gases.

The calorimeter CWD2005-CT from UNION Instruments was approved in 2009 as a calorific value measuring device for custody transfer. It can be used for all gases according to Code of Practice G260/262 of the DVGW (Deutscher Verband der Gas- und Wasserwirtschaft, German Association of Gas and Water Management) for officially verified determination of the calorific value in the range 8.4 - 13.1 kWh/Nm³. Applicable for calibration is the measurement of processed biogas, including gasas which are conditioned by using air and liquified gas.

Use in potentially explosive areas

When calorimeters are used in the oil and gas industry, they are frequently installed in potentially explosive areas. This requires special protective measures in the device technology and corresponding approval by the authorities.

The version CWD2500-DP (Direct **P**urge**)** is designed accordingly and approved as Class1, Div.2 according to NEC500 (USA). The housing has compressed air purging (Type Z) and a safety shutdown.

Figure 8: CWD for potentially explosive areas

CWD Wobbe Measuring Device Series Typical fields of application		
Gas type	**Industry**	**Application**
Biogas Biomethane	Biogas processing Biogas conditioning	Measurement of raw biogas
		Processing into biomethane
		Conditioning of biomethane
Natural gas	Natural gas extraction Natural gas distribution Natural gas usage	Conditioning
		Energy measurement (calibratable)
		Quality measurement
		Calorific value measurement
		Combined systems natural gas/liquefied gas/air
		Measurements at burners: glass industry
		Measurements at burners: steel industry
		Measurements at gas turbines
Blast furnace gases Process gases	Steel industry Refineries	Roller mills
		Sintering plants
		Hot blast stoves
		Power plants
		Lime kilns
		Flares

Figure 7: Fields of application

CWD in use in the production of float glass

The production of float glass is a continuous process. At 1100°C, the glass melt is guided into a bath of liquid tin on which the lighter glass floats. Optimal combustion conditions and a constant temperature of this bath are crucial for a consistently high glass quality. The energy content of the combustion gas, preferably natural gas, varies however over time. By having the CWD permanently determine the energy content and by corresponding compensation with suitable additions, constant flame temperature and stable combustion conditions can be achieved.

UNION Instruments

Company, market presence, support

UNION Instruments is a German company founded in 1919 with headquarters in Karlsruhe and another location in Lübeck. Their activities are characterised by a fast pace of innovations and concentrate on gas measurement technology in process industry with the fields calorimetry (energy content of gases) and gas analysis (composition of gases).

With sales activities in 20 countries, UNION Instruments demonstrates a wide and ever increasing market presence. Apart from the European countries, China and the US are in our focus where we have a high market share in the pertinent market segments. Sales is primarily done via distributors. With modern means of communication and the readiness for intensive travel, our German specialists' knowledge is available world-wide to all interested customers.

Advice before procurement

The modular design of the UNION devices allows customer-specific configuration. To use this potential to the full, we recommend clarifying the future tasks before procurement: For this purpose, UNION Instruments has qualified specialists with years of experience in the applications at your disposal.

Support after procurement

Even the best device technology will not do without qualified service over its long service life. UNION Instruments offers a tiered concept for this:

- Service on the spot by well-trained regionally organised technicians. The number of countries with that service is continuously being expanded.
- Service from the German locations by technicians ready for worldwide travel. Such assignments are at the same time used to support and train the regional technicians.
- Remote maintenance from German with modern tools per mobile telephone and/or internet.

A spare parts service optimised for rapid dispatch and a range of spare part kits and service contracts complete the service range offered by UNION Instruments.

Figure 9: UNION Instruments, device calibration

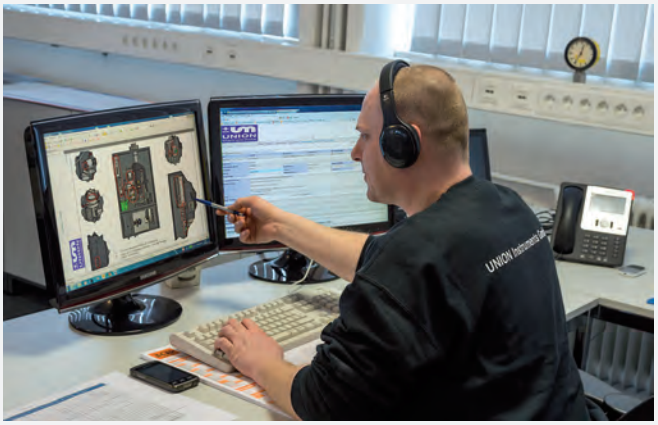


Figure 10: UNION Instruments, customer support

Training during commissioning and in central courses

Even a device equipped to the optimum can only be useful if handled properly. Corresponding training courses are designed to supplement the documentation supplied and today belong to the scope of supply of sophisticated measurement technology.

UNION Instruments offers direct training sessions during the initial startup and additionally or alternatively central training courses for different specific topics.

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